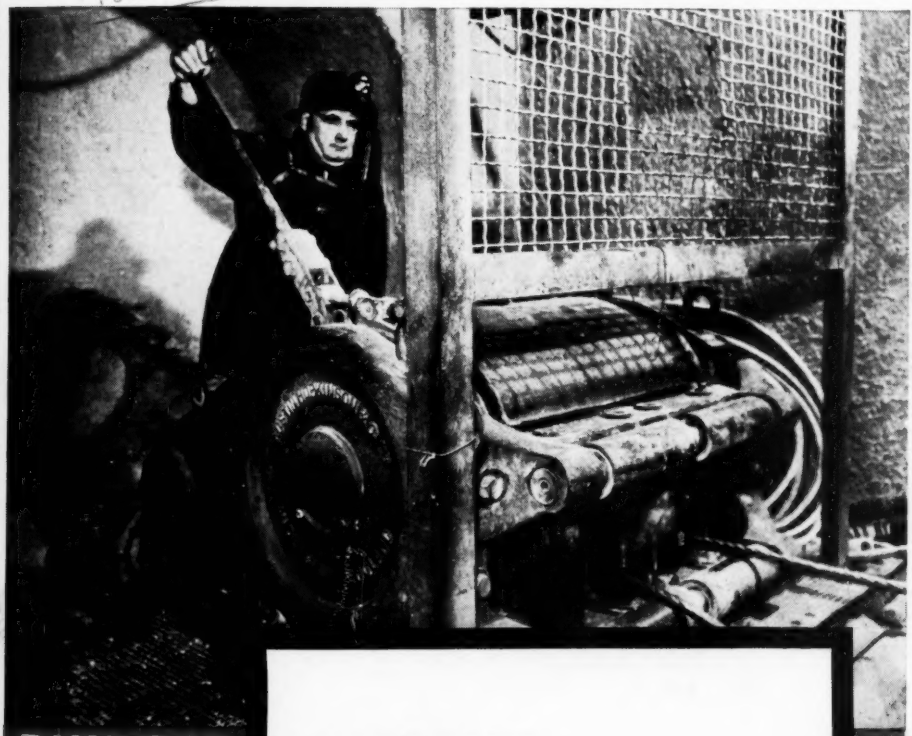
Applied Science Dept.

February, 1960

The Mining Magazine

ST. LOUIS 1960 PUBLIC LIBRARY

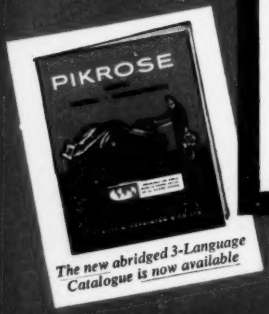
VOL. 102. No. 2. LONDON. PRICE : 3s. ; With postage 3s. 8d.



PIKROSE— a name in mining . . .

FAMOUS THE WORLD OVER

A PIKROSE SLUSHER HOIST gives its operator the maximum return for the human labour put at the back of it. Here we see one at work in a Canadian mine—working with nearly sixty years' design and manufacturing experience behind it.



The new abridged 3-Language Catalogue is now available

AUSTIN HOPKINSON & COMPANY LIMITED

Mining Engineers

DELTA WORKS · AUDENSHAW · LANCASHIRE · ENGLAND

HUWOOD Conveyors

The *best* form of short distance transport

If you do not require a complete conveyor why not try Huwood rollers and/or idler sets on your own structure or as replacements?

HUGH WOOD & CO., LTD.,

Head Office and Factories :
GATESHEAD-ON-TYNE 11.
Grams : Huwood, Gateshead. Tel.: Low Fell 76083 (5 lines)

Industrial and Export Office :
ROYAL LONDON HOUSE, FINSBURY SQUARE, LONDON, E.C.2.
Grams : Huwood Ave., London. Tel.: MONarch 3273

The Mining Magazine

PUBLISHED on the 15th of each month at SALISBURY HOUSE, LONDON, E.C. 2
for MINING PUBLICATIONS, LTD.

Editor : F. HIGHAM, A.R.S.M., M.Sc., M.I.M.M.

Manager : ST.J. R. C. SHEPHERD, A.R.S.M., D.I.C., F.G.S. *Chairman :* H. E. FERN, O.B.E., J.P.

Telephone : *NATional* 6290. Telegraphic Address : *Oligoclase.* Codes : *McNeill,* both Editions, *& Bentley.*

PRICE 3s. ; with postage 3s. 8d. Annual subscription, including postage, 35s. ; U.S.A., $6.00.

Vol. 102. LONDON, FEBRUARY, 1960. No. 2.

CONTENTS

PAGE

EDITORIAL

Notes 66
New Edition of Sinclair's "Asbestos"; United States Mineral Production.

Canadian Uranium 66
A producer's view of the outlook for the metal.

Bore-Hole Surveying 67
A South African invention made available to industry.

Mining in Ghana 67
The outlook for overseas investors examined.

Nickel Position Reviewed 68
A customary year-end assessment of the outlook.

MONTHLY REVIEW 69

METAL PRICES 72

ARTICLES

Fifty Years of Mine Winding
J. C. Christie and A. Shaw 73
Progress towards automatic control is surveyed.

The Present State of the Witwatersrand Controversy .. *C. F. Davidson* 84
A review of recent research

Asbestos in Canada
Hugh G. Jarman 95
A brief account of current activity.

ORE-DRESSING NOTES 98
Jigging (1) ; Design Planning.

BOOK REVIEWS

I.M.M. Symposium "The Future of Non-Ferrous Mining in Great Britain and Ireland" .... *James Russell* 101

Sinclair's "Asbestos" (second edition) *R. A. Mackay* 102

"A Century of Metal Broking" 102

E.D.A. "Process Integration and Instrumentation" 103

ENGINEERING LOG 103

PAGE

NEWS LETTERS

British Columbia 106
Mineral Production ; Cominco ; Conwest Exploration ; Skeena ; Bridge River ; Nicola ; Greenwood ; Nelson ; Ainsworth ; Revelstoke ; Golden.

Eastern Canada 108
Gold Production ; Bancroft Area ; Manitoba ; Quebec.

Australia 108
Oil ; Beryl ; Uranium ; Mount Isa ; New Guinea ; Tin ; Fiji ; Drilling Subsidy.

Western Australia 110
The Edwards Roasting Furnace.

Far East 110
Tin Industry ; Tongkah Harbour ; Pakistan ; China ; India.

Southern Africa 111
South Africa Foundation ; Diamonds ; Training Scheme ; Metallurgy ; Exploration ; Transvaal ; O.F.S.

TRADE NOTES

New Hose Plant 113
Oil-Resistant Tank Linings 113
Pneumatic Elevator for Sands and Heavy Minerals 115
Belt Weighing Machines 116
Overflow Grinding Mill 116

PERSONAL 117

METAL MARKETS 117

STATISTICS OF PRODUCTION 121

PRICES OF CHEMICALS 123

SHARE QUOTATIONS 124

MINING DIGEST

Kerosine Flotation of Coal .... *J. B. Gayle* 125
Manganese in Bombay State, India *S. Roy* 127
Ore-Dressing Progress ..... *N. Weiss* 128

TRADE PARAGRAPHS 129

RECENT PATENTS PUBLISHED 134

NEW BOOKS, PAMPHLETS, ETC. 134

SELECTED INDEX TO CURRENT LITERATURE 135

EDITORIAL

A SECOND edition of one of the standard text-books produced by Mining Publications, Ltd., made its appearance last month. The work, "Asbestos: Its Origin, Production and Utilization," is the subject of an independent review elsewhere in this issue. It is greatly enlarged by the addition of important chapters on primary production and manufacture of asbestos products in North America which, of course, includes Canada, the outcome of a visit paid by the author to those fields since his first edition was published. An extensive revision of the remainder of the text brings the book up to date.

PRELIMINARY figures released by the United States Bureau of Mines show that mineral production in that country for 1959 would be valued at $17,100,000,000, against $16,500,000,000 in the previous year. The outstanding record output of $18,100,000,000 was set up in 1957. Regarding 1959 the Bureau estimates the total value of all minerals produced, including fuels, as 2% higher than in 1958, due largely to increased production in certain lines, since commodity values were generally steady. Non-metal construction materials, crude petroleum, and natural gas contributed most of the increase in total value, the value of the fuels output rising from $11,600,000,000 in 1958 to $11,900,000,000 in 1959. Among the materials registering declines in total value in 1959 were lead, fluorspar, silver, iron ore, anthracite coal, manganese ore, mercury, copper, gold, and chromite. As regards iron ore a 116-day steel strike led to a 12% drop in the value of usable iron ore produced and this was the principal factor in the decline in value of metals output, from $1,597,000,000 in 1958 to $1,550,000,000 in 1959. Large increases in the mining of uranium ore, bauxite, and molybdenum compensated for part of the reduced value for other minerals. A strike in the copper industry, however, reduced the quantity of refined copper from United States mines by nearly 16%. Lead and zinc quantities also dropped, but the combined total value of copper, lead, and zinc rose slightly because of higher prices.

Canadian Uranium

Early in January a first Canadian Uranium and Atomic Energy Conference was held, the principal outcome of which was the formation of a permanent forum for the exchange of ideas and information. Indeed such was the success of the conference that it is possible that it may become a yearly event.

One of the speakers in Toronto was Mr. A. F. Lowell, head of the marketing department of the Rio Tinto Mining Co. of Canada, Ltd. He pointed out that nearly all the uranium mined and refined in the western world to-day is bought by governments under long-term contracts and is strictly under the control of governments. Historically, Mr. Lowell suggested, government control arises from the fact that uranium production in the early years was used exclusively for military purposes, but, he said, some years have now passed since the metal could be described as a purely military material, since great progress had been made in perfecting nuclear power plant systems, fuelled by uranium, for the generation of electricity for civilian purposes. In this connexion a great number of research reactors were now operating throughout the world. Indeed, it might be forecast that in the relatively near future most nuclear power plants would be designed, financed, built, and operated by private industry.

There were thus, Mr. Lowell said, two definite trends—the one towards the predominance of civilian, as opposed to military, applications of nuclear power and the other towards the predominance of private industrial activity in the nuclear field. In his view, however, commerce in uranium was still throttled by excessive governmental restrictions and failure to permit a far more liberal regime for trading in the metal could have serious consequences. The industry was approaching the stage when uranium should be regarded as an internationally merchantable item. Some recognition of that fact had been given by various western governments, but controls on "private sales" were so rigorous as to make the conclusion of business extremely difficult.

Canadian uranium producers, Mr. Lowell concluded, were, more than any others, in urgent need of a far more liberal system for trading in the metal which would permit them to develop new markets. The logical step for Canada and Canadian uranium producers, he said, was to abandon the system of its sale under bilateral agreements, which were in his opinion now pointless.

Bore-Hole Surveying

Mining men everywhere will be interested to know that a bore-hole survey instrument using electronic principles for continuously recording the direction and inclination of small-diameter bore-holes down to depths of 10,000 ft. has been developed in South Africa by the Union Corporation, Ltd. As is known, many instruments used to date for bore-hole surveys employ a magnetic compass and inclinometer, the deviations of which are recorded photographically in the body of the instrument. Single records are obtained, requiring the lowering of the instrument down the hole and removal from the hole for each measurement. More refined instruments have used multi-shot cameras with a timing mechanism, usually clockwork, to photograph the direction and inclination at pre-determined depths down the hole. A facility has often been provided whereby the bottom of the hole is marked by a scratcher, the direction of the scratch mark serving to orient the core when removed from the hole. Knowing the direction and inclination of the hole and orientation of the scratch, true dips of strata can be determined. This facility can also be provided on the electronic bore-hole survey instrument.

The bore-hole survey instrument now available provides a continuous electronic record at the surface from which inclination and direction of the hole can be determined at any desired depths down the hole. The compass of the new instrument uses the well-known flux valve principle, ambiguity of recording being avoided by using two flux valves at 90° to each other, although any preferred angle may be used. The system rotates with the body of the instrument but in a horizontal plane. Changes of magnetic flux as each unit sweeps through the earth's horizontal field produce changes in certain parameters of the oscillating current fed to the units. The recording of one or other of these parameters determines the direction of each unit at each instant of time. These recordings alone give only the orientation of the instrument barrel, but when used in conjunction with the inclinometer records they will determine the direction of deviation of the hole. Two inclinometers are provided, each moving in a plane mutually at right-angles to that of the other, the planes of movement being in the direction of the instrument barrel and therefore of the bore-hole. The movement of an inclinometer changes the inductance of a system of coils in a bridge circuit and an electrical recording is obtained at the surface for each inclinometer. The resultant of the two recordings determines the inclination of the bore-hole. As the planes of the inclinometers are fixed in relation to the position of the flux valves, and all are fixed within the barrel of the instrument, the orientation of the instrument in the hole is known and the direction of the hole is then determined. The continuous record provided by the new instrument can either be picked at any desired interval and the hole inclination and direction determined by simple calculation or from charts, or further electronic means can be provided to give these parameters directly on a continuous record.

The new instrument developed by engineers of the Union Corporation will undoubtedly be of immense value to any company concerned with drilling operations. In the circumstances it is good news to learn that the Corporation will be happy to assist any engineer wishing to develop the device for his own use.

Mining in Ghana

At a meeting held in London last month Mr. C. J. Burns, chairman of a number of companies operating in Ghana, announced that the Government had agreed to advance up to £150,000 to one of these companies, Amalgamated Banket Areas, for a three-year period. Subject to certain conditions the loan will nevertheless be of great help to the operating company and Mr. Burns went on to make appreciative reference to the steps the Ghana Government was taking in its endeavour to attract expatriate capital. He pointed out, for instance, that pioneer industry legislation had been enacted and that many United Kingdom interests had already taken advantage of that concession, while repatriation of overseas capital had been guaranteed. In addition Ghana's second Development Plan had explicitly emphasized the part that could be played by overseas capital in its development and to further that purpose the Government had set up an Investment Promotion Board with the sole purpose of assisting prospective investors and of reviewing investment inducements. At the same time, to ensure that future expansion was channelled along sound financial lines, the Government had begun discussions with representatives of the London Stock Exchange with the aim and purpose of setting up a Stock Exchange in the country.

As far as the gold mines were concerned, Mr. Burns said, full co-operation was to be forthcoming. With the first £200,000 grant to be made Amalgamated Banket Areas had been enabled to carry through its provisional development programme and withstand increased costs, while Ghana Main Reef, which had received a minor advance, had used it to the greatest advantage. In addition Bremang Gold Dredging was now in a position to operate its four dredges in their present courses to the end of their working life, while the company first named, as a result of the latest advance, could now spend on development the largest sum per year of any gold mine in Ghana, with the prospect during the next three years of greatly-improved ore reserves and the examination of parts of their lease area which have been so far unexplored. Mr. Burns was emphatic that to the best of their endeavours the mines would match the assistance of the Government with equal courage in order to enter into full partnership.

Nickel Position Reviewed

Concluding his customary year-end review of the world nickel situation Dr. John F. Thompson, chairman of the board of directors of the International Nickel Co. of Canada, Ltd., this year points out that the effectiveness of renewed efforts to increase the consumption of nickel through augmented marketing and research activities is evidenced by the increased use of the metal during 1959. "Its versatility," he says, "is making possible many new and promising applications. As far as International Nickel is concerned, these efforts will be continued with vigour, not only to assure markets for present supplies of nickel, but also for the largely increased supplies which will be forthcoming by 1961." In the circumstances, Dr. Thompson, concludes, "it is expected that 'free world' nickel consumption in 1960 will show a substantial increase over that of 1959." In the year just concluded, the chairman said, the "free world consumption of nickel exceeded 400,000,000 lb., or about 25% over the 320,000,000 lb. consumed in the previous year. However, despite the substantial rise in 1959 consumption and the uncertainties in Cuba, free world supplies of nickel continue ample."

Referring to the production capacity of the world outside the iron curtain Dr. Thompson went on to say that this was at an annual rate of about 550,000,000 lb., a "capacity, based on presently planned programmes, expected to increase by more than 100,000,000 lb., or 18%, in the next two years." He thought that during the second half of 1959 "the changed political situation in Cuba introduced an element of confusion in that country's nickel industry which has not been entirely resolved and the forecast for increased capacity is made with this fact in mind." At the same time the International Nickel project at Thompson, Manitoba, would contribute 75,000,000 lb., the Thompson project thus taking on added significance in the light of the current situation in Cuba. Canada continues to be by far the largest supplier of nickel of the free world's present operating capacity, the Dominion accounting for over 70%; with Cuba, 10%; United States, 4%, and New Caledonia, Japan, and other sources the remainder. In a further reference to Cuba Dr. Thompson pointed out that in September last the General Services Administration of the United States Government had announced that it would offer for sale its Nicaro nickel plant and was ready to receive purchase proposals up to December 1 last. In its announcement the Administration said that the plant was capable of producing nickel at an annual rate in excess of 50,000,000 lb. (metal content) in the form of nickel oxide powder and sinter. Early in December it was stated that responses had been received from private industry and that an interest in acquiring the plant had been expressed by the Cuban Government. In its announcement the Administration also said that "a considerable period of time may be required to determine whether a sale acceptable to the United States Government can be concluded." Meanwhile, Dr. Thompson points out that the development of the project at Thompson is proceeding according to plan. It was expected to come into full-scale production in 1961 at an annual rate of 75,000,000 lb. of nickel and would constitute the biggest nickel-producing operation in the world next to the company's existing plant in the Sudbury District. He continued: "Capital expenditures by Inco alone for the mining project, which is being financed entirely by company funds without Government assistance, will exceed $115,000,000. Including other investments connected with the Thompson project, total initial expenditures will amount to $175,000,000, the largest single investment in Manitoba."

MONTHLY REVIEW

Introduction.—At the time of writing it seems likely that the railway strike threatened to start on February 15 will take place and there is in consequence a worsening of business confidence, not helped by conditions in the United States. With industry buoyant, however, commodity prices remain firm, copper particularly, principally because of fears of further strikes in the Americas.

Transvaal.—The output of the South African gold mines for December has been returned as 1,662,043 oz., making with 31,309 oz. from outside producers a total of 1,693,352 oz. for the month. At December 31 there were 354,058 natives at work in the gold mines, as compared with 358,746 at the end of November. The producers' profit for the December quarter is reported as £30,359,937, £21,399,331 of this amount credited to the gold and uranium producers.

At the end of January shareholders of VAAL REEFS EXPLORATION AND MINING were informed that the Vaal Reef had been intersected in the No. 2 Main Vertical shaft at approximately 4,880 ft. below surface. The Reef, which dips at 8° to the south, was completely exposed around the perimeter of the shaft and, on sampling, gave an average value for gold of 36·69 dwt. and for uranium of 1·90 lb. per ton over a channel width of 22·33 in. It has also been announced that the Vaal Reef was intersected at approximately 200 ft. south of the No. 2 Main Vertical shaft in the 50 S.E. Haulage driven from the No. 1 Main Sub-Vertical shaft. Up to January 29, 585 ft. of reef development sampled gave an average of 49·80 dwt. gold and 2·14 lb. uranium per ton over a channel width of 17·21 in. Some 88% of the footage sampled proved payable with an average value of 55·83 dwt. gold and 2·39 lb. uranium per ton over 17·25 in.

On February 4 the directors of MODDERFONTEIN EAST announced that, owing to the persistent decline in the available tonnage of ore reserve, it had become increasingly difficult to maintain mining operations at a profit. They say that because of the virtual completion of the development programme and to the narrow margins on which the mine has been operating for some time, there is little hope under existing conditions of any improvement in the position. In these circumstances it has been considered necessary to give the statutory three months' notice to the Government, in terms of the Gold Law, of the possible discontinuance of mining operations.

At an extraordinary meeting of MODDERFONTEIN B GOLD MINES, to be held on February 22 in Johannesburg, shareholders are to be asked to approve of a provisional agreement concluded with the Government of the Union of South Africa whereby the Government has been granted a lease of, with an option to purchase for the sum of £95,000, the company's mine village, which comprises all the buildings, light, water and sanitary installations, erections, and other immovables situate on approximately 124 morgen of the farm Modderfontein No. 76 I.R. in the district of Benoni.

The accounts of the BLINKPOORT GOLD SYNDICATE for the year ended September 30 last show a profit of £553,607 and a total of £577,059 available. Dividends equal to 4s. 4½d. a share require £546,875.

The S.A. COAL, OIL, AND GAS CORPORATION which at June 27, 1959, had expended about £48,000,000 on capital works, etc., expects its total sales to improve to about £7,500,000 in the 1959–60 year, against £6,722,000 in 1958–59 and £4,834,000 in the previous period. The 1958–59 depreciation allowance was given as £4,706,000 as against £3,410,000 in last financial year. A profit-and-loss account has not yet been published. Despite the fact that certain units in the consolidation scheme will only be commissioned in 1961, the major portion of the project should be completed by the end of 1960. While many problems await their long-term solution production is nearly on an even keel and increasing attention is now being paid to chemical developments. Negotiations are proceeding for further processing of propylene, ethylene, methane, and hydrogen; for the local processing of crude tar acids into pure carbolic acid, cresylic acid, and higher tar acids; a newly formed company will process oxygenated organic chemicals, and the recovery of higher alcohols with carbon numbers from 5 to 14 is being considered. Last year's output of petrol is not available.

In the three months to December 31 last DOMINION REEFS (KLERKSDORP) treated

119,500 tons of ore and produced 132,029 lb. of uranium oxide. The working profit for the period is given as £257,304.

In a recent statement Mr. D. A. B. Watson, chairman of RUSTENBURG PLATINUM MINES, pointed out that the company's production policy is dictated both by the volume of sales and by the need to maintain stocks of refined platinum at a desired level. To this end the rate of production is to continue to be adjusted in the light of estimates of changes in the situation from time to time. The Waterval reduction plant, completed in 1957 and not as yet commissioned, is fully maintained, he said, and is available for immediate use, while the output from the two mines operated is capable of further expansion at short notice as and when required to meet the full capacity of the reduction plant.

In the December quarter the ROOIBERG MINERALS DEVELOPMENT COMPANY recovered 273 long tons of tin concentrates for an estimated working profit of £19,831.

MESSINA (TRANSVAAL) DEVELOPMENT produced 254,223 tons of ore containing 3,454 tons of recoverable copper in the period.

Orange Free State.—At the annual meeting of WESTERN HOLDINGS held in Johannesburg last month the chairman said that expenditure on the drilling programme south of Vaal Reefs, other than bore-hole GZ.1, which was being drilled jointly with FREE STATE DEVELOPMENT AND INVESTMENT CORPORATION, was being borne by Western Holdings. The area being prospected was, however, subject to an agreement between the company and the UNION CORPORATION and, in certain circumstances, the secretarial or technical services of any new company formed to exploit this particular area would be undertaken by that Corporation.

Southern Rhodesia.—In order to raise funds for an accelerated development programme the directors of FALCON MINES have decided to increase the company's capital to £499,293 by the issue of 181,561 new 5s. shares. These are to be offered to existing holders at 8s. a share in the ratio of one new share for every ten held. In a circular giving notice of the offer it is stated that now that the projected increase in mill tonnage has been accomplished the company is in a position to give more attention to the exploration of other areas along the strike, which is approximately 4½ miles in length. A shaft on the Pixy section had been sunk to 380 ft. by the end of September, 1959, and reef development from this shaft has since given favourable results. The shaft is to be deepened during the current financial year to about 500 ft. and this will assist in finding the trend of values on which further development can be based. At the Western end of the strike the examination of the workings of the old Arlandzer mine has commenced and there are indications that the reef there is very similar to the Dalny reef.

In the three months to December 31 last M.T.D. (MANGULA) milled 270,000 short tons of ore and recovered concentrates containing 2,987 tons of copper.

The BRITISH SOUTH AFRICA COMPANY announced last month that its estimated gross revenue from mineral royalties, rents, and fees for the quarter ended December 31, after providing for the payment to the Northern Rhodesia Government of 20% of the net revenue derived from the exercise of its Mineral Rights in Northern Rhodesia, amounted to £2,670,000. (Quarter ended December 31, 1958—£1,489,000.)

Northern Rhodesia.—In a recent circular shareholders of the RHODESIA BROKEN HILL DEVELOPMENT COMPANY have been informed that it has been decided to go ahead with the installation of the Imperial Smelting furnace, the operation of which is expected to lower the cost of production and to improve the combined recovery of lead and zinc from currently mined ore from about 60% to over 85%. In addition, some 200,000 long tons of these metals will be recovered from the accumulated stocks of high-grade oxidized products which are at present untreatable. It is estimated that provided work is started immediately the new process can be brought into commission early in 1962. The cost of the project including additional housing will be approximately £4,000,000 and consideration is now being given to the best way of providing the funds required.

In the December quarter MUFULIRA COPPER MINES produced 23,540 long tons of copper and CHIBULUMA MINES 5,276 tons. Mufulira's profit, before taxation, is estimated as £2,008,000 and that of Chibuluma as £493,000. In the same period ROAN ANTELOPE COPPER MINES produced 22,272 long tons of copper for an estimated profit of £1,564,000.

Ghana.—With the recent dividend notice shareholders of the ASHANTI GOLDFIELDS CORPORATION were told that the profit for the year ended September 30 last, after all charges, is £976,180, subject to final audit. In the report for the December quarter it is

stated that the circular ventilation shaft should be completed to the 32 level in the current period.

The operations of GHANA MAIN REEF in the year to June 30 last resulted in a profit of £74,828.

Nigeria.—The report of JANTAR NIGERIA for the year ended September 30 last shows the output for the year as 147½ tons of cassiterite and 232 tons of columbite. Operations resulted in a profit of £21,681 and of the £41,544 available a dividend equal to 4½d. a stock unit requires £20,672. Ore reserves are given as 1,404 tons of cassiterite and 1,796 tons of columbite. In his statement accompanying the report and accounts the chairman says " the demand for columbite, particularly for the grade of ore which your company produces, has increased during the year, and slowly rising prices for the year's output have been obtained. Contracts have been entered into for the whole of the output for the year 1959–60 at prices to be negotiated quarterly. On the assumption that the future demand for columbite will at least be maintained and may increase, it has been decided to start working our primary deposit on an experimental basis." He went on to say that no work had been done on the basalt lead during the year, but pointed out that there are some 2,000 tons of tin indicated still to be won from the lead, in addition to that shown in the report.

Tanganyika Territory.—In Progress Report No. 64 shareholders of KENTAN GOLD AREAS are informed that in the three months ended December 31 last GEITA GOLD MINING milled 56,980 tons of ore and recovered 10,890 oz. of gold. The working profit for the period is given as £14,736.

The Mines Department announces that for the first time for nearly 20 years—since 1941—exports of gold bullion from Tanganyika for 1959 are estimated to be worth £1,000,000, while the estimated value of all mineral exports for last year is 6% higher than the corresponding figures for 1958—£6,743,481, against £6,341,787. This increase is due to higher exports of diamonds, gold, and tin concentrates. At the same time the estimated value of exports *plus* local sales from domestic production is £7,100,000—another Territorial record. Diamond exports for January to December, 1959, are estimated to be 554,951 carats, valued at £4,483,700, as compared with 515,453 carats, valued at £4,415,055 in 1958. The export of tin concentrates was also expected to show a substantial rise, with an estimated figure of 93·21 long tons, valued at £50,024 in 1959, against £13,471 in 1958. Exports of mica, estimated value £52,204, show a slight rise over the £51,226 figure for 1958, while on the other hand exports of lead concentrates were slightly down—£944,500, compared with £1,029,279 in 1958.

Australia.—Late last month the directors of NORTH BROKEN HILL announced that, subject to obtaining stockholders' consent to an increase in the nominal capital, they have decided to make a bonus issue of nine fully-paid ordinary shares of 5s. each for every 5s. unit held and, following the issue, to consolidate the capital of the company into shares of 10s. each. The issue is to be paid out of a reserve which will be created by revaluing the investments held by the company. An extraordinary meeting is to be held to increase the capital.

At the annual meeting of the LAKE GEORGE MINING CORPORATION last month the chairman said that, as part of a general survey reviewing ore possibilities within reasonable distance of the mine, a programme of surface geochemical prospecting had been started last August and had indicated some hopeful areas to the south of Keatings, on the line of extension of the known ore-bodies, although three drillholes so far put down had proved negative. Apart from the tonnage indicated in the extension of Elliot's ore-body below the 2,030-ft. level no major new ore had been found, " despite unrelenting efforts in examining all reasonable prospects."

Government estimates for surface deposits of high-grade iron ore in Western Australia are put at 275,000,000 tons. An equal quantity of low-grade (30%–50% Fe) also exists. The figures given are " a guide only," it is emphasized, because sufficient work for accurate evaluation has not been done to enable the Government Geologist to complete a report.

In the December quarter MOUNT LYELL MINING AND RAILWAY treated 500,681 tons of ore and recovered 13,161 tons of concentrates containing 3,022 tons of copper. In the period 3,358 tons of blister copper was produced, containing 10,912 oz. of silver and 2,057 oz. of gold.

Dominican Republic.—The first shipload of bauxite to be exported from the Dominican Republic was reported nine months ago. Further shipments to the ALUMINUM CO. OF AMERICA's new Point Comfort alumina

refining plant are proceeding as planned. The bauxite is loaded at Cabo Rojo and transported to the seacoast loading station.

Canada.—With the recent dividend notice directors of the INTERNATIONAL NICKEL CO. OF CANADA recommend for approval by the shareholders at the annual meeting in April that the shares of the company be split on a two-for-one basis. They announced that it was expected that the new shares would carry a quarterly dividend of 37½ cents per share, assuming continuation of the current outlook. The expected quarterly dividend on the new shares would total $1·50 per year, equivalent to $3·00 per share on the present shares.

Burma.—In the three months ended September 30 last the BURMA CORPORATION (1951) milled 32,651 tons of ore and produced 4,328 tons of refined lead, 387,582 oz. of silver, 108 tons of copper matte, 156 tons of nickel speiss, and 4,568 tons of zinc concentrates. The estimated profit for the quarter is given as K. 6,82,900 (£51,218), which compares with K. 12,27,500 (£92,063) for the previous three months. The directors of the Corporation state : " It is regretted that, owing to circumstances beyond our control, there was a serious decline in mine output for the months of November and December, 1959, which will result in a reduction in the quantities of refined lead, silver, and zinc concentrates to be produced in the quarter ending March, 1960."

Mexico.—Shareholders of SAN FRANCISCO MINES OF MEXICO have been informed that operations in the year to September 30 last resulted in a profit of £133,514, which compares with a loss of £207,959 in the previous year. It is added that : " At the end of the year the company held abnormally high stocks of refined lead and of zinc concentrates. Since then it has been necessary to finance further increases in stocks and accordingly, notwithstanding the modest profit earned, the directors regret that they are unable to recommend the payment of a dividend."

DIVIDENDS DECLARED

(Less Tax unless otherwise stated)
* Interim. † Final.

***Amalgamated Metal Corporation.**—3%, payable Feb. 29.
***Amalgamated Tin Mines of Nigeria.**—8%, payable Mar. 18.
†Anglo American Investment Trust.—10s. and 5s. bonus, payable Mar. 15.
†Ashanti Goldfields Corporation.—1s., payable Mar. 31.
***Ayer Hitam Tin Dredging.**—4½d., payable Feb.24.
†Bibiani (1927).—5%.
†Borax (Holdings).—4½d.
†British South Africa Co.—4s. 6d., payable Mar. 26.
†British Tin Investment Corporation.—16%, payable Mar. 25.
†Fanti Consolidated Investment.—10% and 6% bonus.
***Geevor Tin Mines.**—6d., payable Mar. 8.
***Ghana Main Reef.**—7½%, payable Mar. 11.
***Idris Hydraulic Tin.**—1½d., payable Feb. 12.
International Nickel Co. of Canada.—Quarterly 75 cents, payable Mar. 21.
†Jantar Nigeria Co.—4½d., payable Feb. 16.
***Johannesburg Consolidated Investment Co.**—1s. 6d., payable Mar. 24.
***Kaduna Prospectors.**—2d., payable Feb. 22.
***Kaduna Syndicate.**—2d., payable Feb. 22.
***Kamunting Tin Dredging.**—10%, payable Mar. 4.
***Kentan Gold Areas.**—1s. 6d., payable Mar. 11.
***Kinta Kellas Tin.**—5%, payable Feb. 22.
***Malayan Tin Dredging.**—3d., payable Mar. 1.
***Mount Morgan.**—1s. (Aust.), payable Mar. 31.
†Orange Free State Investment Trust.—2s. 9d., payable Mar. 15.
***Petaling Tin.**—10%, payable Feb. 27.
†Pronto Uranium Mines.—60 cents, payable Apr. 20.
***Rambutan.**—3d., payable Feb. 12.
***Southern Malayan Tin Dredging.**—3d., payable Feb. 26.
***Southern Tronoh Tin Dredging.**—6d., payable Feb. 17.
***Sungei Besi Mines.**—1¾d., payable Feb. 23.
***Taiping Consolidated.**—15%, payable Feb. 12.
***Tanjong Tin Dredging.**—6d., payable Feb. 13.
***Tronoh Mines.**—6d., payable Feb. 19.
†Vereeniging Estates.—5s. 6d., payable Mar. 18.
†West Rand Investment Trust.—2s. 3d., payable Mar. 15.

METAL PRICES

February 9.

Aluminium, Antimony, and Nickel per long ton ; Chromium per lb. ; Platinum per standard oz. ; Gold and Silver per fine oz. ; Wolfram per unit.

	£	s.	d.
Aluminium (Home)	186	0	0
Antimony (Eng. 99%)	190	0	0
Chromium (98%–99%)		7	2
Nickel (Home)	600	0	0
Platinum (Refined)	30	5	0
Silver		6	7½
Gold	12	10	4½
Wolfram (U.K.)		—	
(World)	7	17	6

Tin, Copper, Lead, Zinc } See Table, p. 120.

Fifty Years of Mine Winding

J. C. Christie [1]
A. Shaw [2]

An account of progress towards the present day use of automatic control.

Summary

The article starts by describing briefly the position of the electric winding engine 50 years ago. The additions and changes which were applied in subsequent years to improve the performance and efficiency of the equipments are then covered, thus bringing the reader to the present day, with the wide application of closed-loop controls, automatic working, and the increased use of static equipment.

Introduction

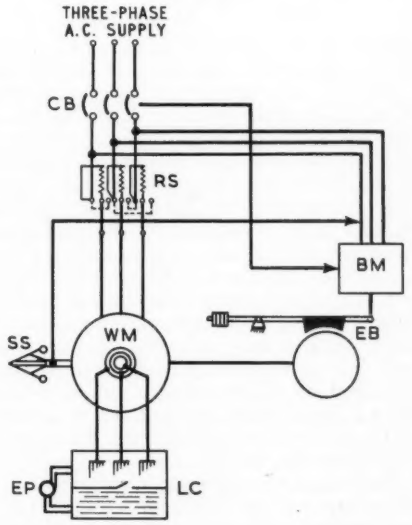
Coal has been and still is the largest source of energy for Britain's economy despite a recent lowering in its percentage of the total. However, the extraction of coal is only part of the mining industry. The addition of iron-ore, the base metals, gold, and uranium to mention only a few of the multitude of minerals won from the ground, has been the basis of the increased wealth and rise in standards of living throughout the world.

On a Golden Jubilee occasion, therefore, it is appropriate to review the progress made during the past 50 years in the application of electric winding engines. Although the subject of the present article is limited to electric winder controls, the principle of continuous development which has taken place in the mining industry is well illustrated by the advances in this particular field. The trend towards increased safety, greater reliability, consistent performance, and automatic operation typifies the progress which many industries have achieved to make their contribution towards increased production, improved quality of product with reduced costs, and towards the general well-being of their countries as a whole.

Early Days

Fifty years ago, in 1909, the electric motor was already well-established as a means of motive power. The steam engine was probably the most frequently encountered type of drive in mines, but the electric motor was being used on an increasing scale. The first electrically-driven winding engines were installed as late as 1900, long after electric power was first introduced. This delay was due to a reluctance on the part of mine owners to change over to a new and untried system—somehow this has a familiar ring.

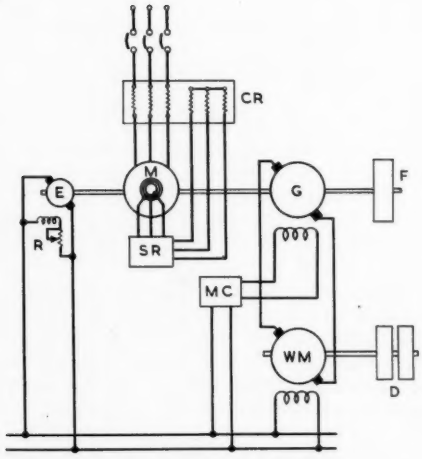
The early drives were manually controlled three-phase a.c. or Ward Leonard d.c., either with or without an Ilgner controlled motor-generator set. The decision on which type to use largely rested on the principal winding



WM - Winder Motor
LC - Liquid Controller
RS - Reversing Switch
EB - Emergency Brake
CB - Circuit Breaker
BM - Brake Mechanism
EP - Electrolyte Pump
SS - Speed Switch

Fig. 1.

[1] Chief Engineer, Mining Division, English Electric Co., Ltd.
[2] Deputy Manager (Tendering), Mining Division, English Electric Co., Ltd.



WM – Winder Motor
CR – Current Relay
G – Generator
M – MG Set Motor
E – Exciter
F – Flywheel
SR – Slip Resistance
R – Regulator
MC – Master Controller
D – Winder Drums

Fig. 2.

duties and the power supply available to the mine. The installation of the a.c. winder was restricted on account of the torque/slip characteristics of the a.c. induction motor and the lack of an efficient form of electrical braking. Furthermore, with the a.c. winder slow-speed running was difficult and, where large masses were involved, the three-phase motor was very inefficient. Both economic speed control and electrical braking without severe shock on the moving system could be obtained inherently by using a Ward Leonard drive. This was very important, as the mechanical braking systems of that time were not so reliable as they are nowadays. The similarity between the steam winder and the a.c. drive was striking, as the smoothness and control of the wind depended largely on the skill of the driver.

Typical basic schematic diagrams of two early winders are shown in Figs. 1 and 2. On the three-phase equipment (Fig. 1) an oil circuit breaker protects the motor against overloads, with the direction of rotation accomplished by a reversing switch, either air or electrically operated. The resistances shown prevent excess surge voltages which accompany the switching duty. The liquid resistance shows the fixed top plates and the pump arrangement for transferring the electrolyte from the lower to the upper part of the horizontally divided tank, the resistance decreasing as the liquid rises in the upper half of the tank—a fairly slow operation. Protective features are incorporated which apply the emergency brake, trips being arranged for either an overspeed, supply voltage failure, or operation of overwind switches. When the brake is applied the motor is disconnected from the supply. Some installations also had a device for limiting excessive speeds when approaching the bank.

The circuit of Fig. 2 is self-explanatory with the current relay in the stator circuit of the M.G. set driving motor initiating the insertion of rotor resistance so that when load is applied the speed of the motor-generator set drops and the flywheel gives up its energy. This had the effect of greatly reducing the peaks of power reflected back on to the supply and it was the preferred method of control. It is interesting to note that the regulator R which adjusts the voltage of the exciter was termed an automatic shunt regulator.

One other factor which influenced the early electric winders towards Ward Leonard control was that on practically all the steam winders the main connecting rods and cranks were directly coupled to the winder drum-shaft. Reduction gearing between the driving-motor and drum was not so readily accepted on the first equipments and since the slow-speed a.c. motor had poor efficiency and power factor the direct-coupled d.c. motor with Ward Leonard drive was preferred. Nevertheless, a few small direct-coupled a.c. winders were installed.

On the mechanical side, when the electric motor first began to supersede the steam engine, little difference was made to the drum or friction pulley and the fundamental brake gear designs which had been established for steam winders. The types of drive, whether Koepe or single rope friction, reel or bobbin with flat rope, or drum had all been in operation with steam winders and in many respects the criteria determining the choice of mechanical system were unaffected by the introduction of the electric winder. The significant problem was the effect of the cyclic duty on the restricted capacities of the various electrical power supply systems and this situation continued to be of considerable importance for some 30 years. Even to-day, when extensive grid networks

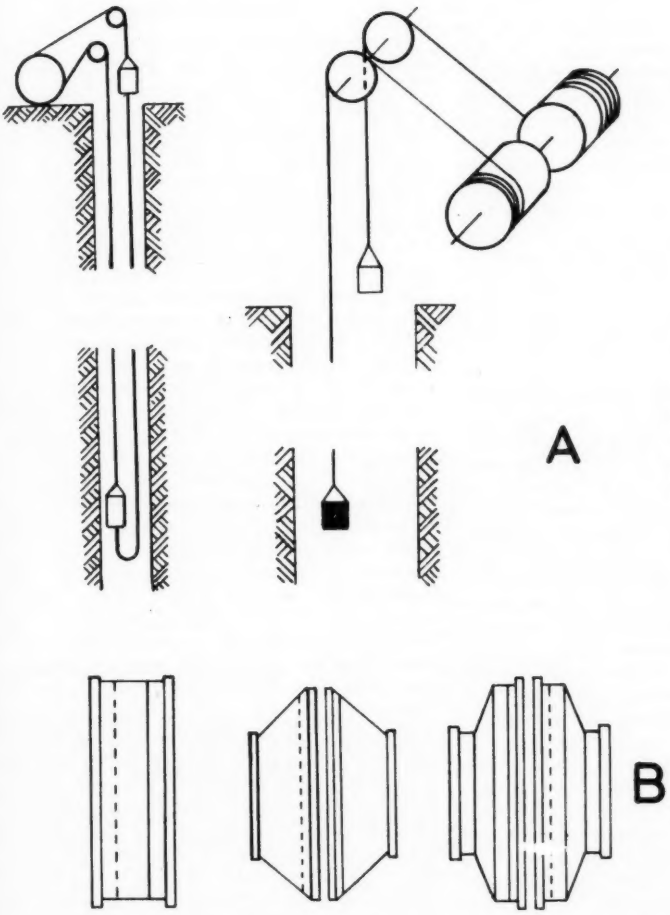


Fig. 3.—
(A) Friction Winder with Balance Rope (left) and Double-Drum Winder.
(B) Types of Winder Drum.

are in service in the majority of the world mining areas the initial problem still partially remains, with restrictions being encountered in the installation of mercury-arc converter winders.

On the Continent, where friction winders had been common, power supply limitations were less severe than where drum winders were employed. This was due to the use of balance or tail ropes and the lower mechanical inertia of the former method. The arrangement shown in Fig. 3 (*a*) shows the balance rope on the friction winder and a typical double-drum winder arrangement for multi-level winding. Where drum winders were the more common installation various forms of conical drum were adopted in addition to a growing use of balance ropes on single parallel drum winders, in an attempt to reduce the peak kilowatts required. Fig. 3 (*b*) shows some types of drum employed—*i.e.*, cylindrical, conical, and bi-cylindro-conical (B.C.C.) the last two being used to reduce the accelerating horse-power required at the beginning of a wind. These shaped drums originated with steam drives for the same purpose and their use was continued despite a vastly more complicated mechanical construction.

With d.c. winder motors, Ilgner sets were employed to equalize the demand on the supply, but for many years only the a.c. induction motor with slip regulator equipment could be used as the motor-generator

set driving medium. To obtain the benefit from the ability of a synchronous motor to operate at leading power factor it was necessary for a non-flywheel Ward Leonard set to be used until a hydraulic slip coupling scheme was developed. In this arrangement a scoop coupling was connected between the a.c. motor and the flywheel part of the generator set, the slip of the coupling (and hence the flywheel speed) being regulated by varying the quantity of oil in the coupling. The oil quantity was controlled relative to the load on the a.c. motor, whose speed remained at synchronous value.

An interesting development on the basic Ward Leonard equalized system was the use of a high-speed steam turbine to drive the variable-voltage generator feeding the winder motor. This arrangement combined the advantages of Ward Leonard electrical control with independence from an electrical supply system. It was usual, however, to connect an a.c. induction motor to the generator set to act as an electrical brake, absorbing the excess energy beyond that which would raise the flywheel speed to full value during conditions of regenerative braking. When maintenance was required on the turbine the a.c. motor operated as the driving member with normal slip control gear, so enabling winding operations to continue.

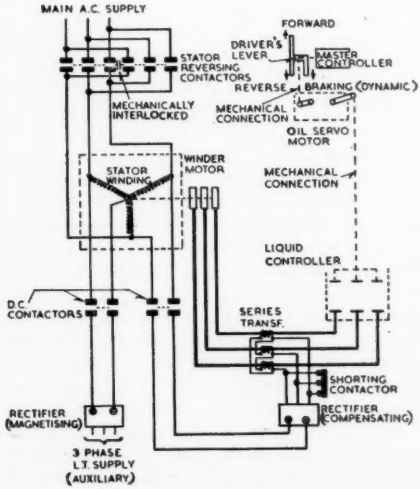


Fig. 4.

Dynamic Braking

The most progressive step in electrical control between the two World Wars was the development of d.c. dynamic braking of a.c. winders. Prior to the introduction of this form of electrical braking the a.c. winder was restricted in its use not only by its high power demand over the whole of the accelerating period but also by the inefficient methods available for service braking. The only forms of braking which could be adopted were mechanical, which resulted in excessive lining wear, and electrical counter-current. The latter, apart from being inefficient, also resulted in high induced mechanical stresses in the whole system and difficult speed control. It was inevitable, therefore, that for large winders Ward Leonard control had to be adopted and also for those installations where lowering duty formed a major part of the operations. Nevertheless, this period coincided with a time when capital investment was being restricted and many installations were limited in design so that the cheaper a.c. winder could be adopted. The development of dynamic braking was of prime importance since, even with the additional equipment required, the initial cost of an a.c. equipment was considerably less than that of a Ward Leonard for the same duties.

The principle of dynamic braking is now well known and a typical schematic diagram incorporating this feature is shown in Fig. 4. When an induction motor is connected to the a.c. supply system it can only run at a speed corresponding to the motor torque/slip characteristics. If the load torque becomes negative the rotor will attain super synchronous speed and the insertion of additional external rotor resistance will result in increase of speed. By disconnecting the stator from the a.c. supply, and applying d.c. to one or more stator phases, the motor operates as an asynchronous alternator, being driven by the overhauling load, and produces an a.c. voltage at the sliprings at a frequency depending on the speed of the rotor and the number of poles for which the motor has been wound. The normal external rotor resistance which is used for speed control during motor operation is used as the loading resistance during dynamic braking and in this resistance the energy of the load is dissipated. Fig. 5 illustrates the relative energy drawn from the supply and energy dissipated in the rotor resistance with counter-current and dynamic

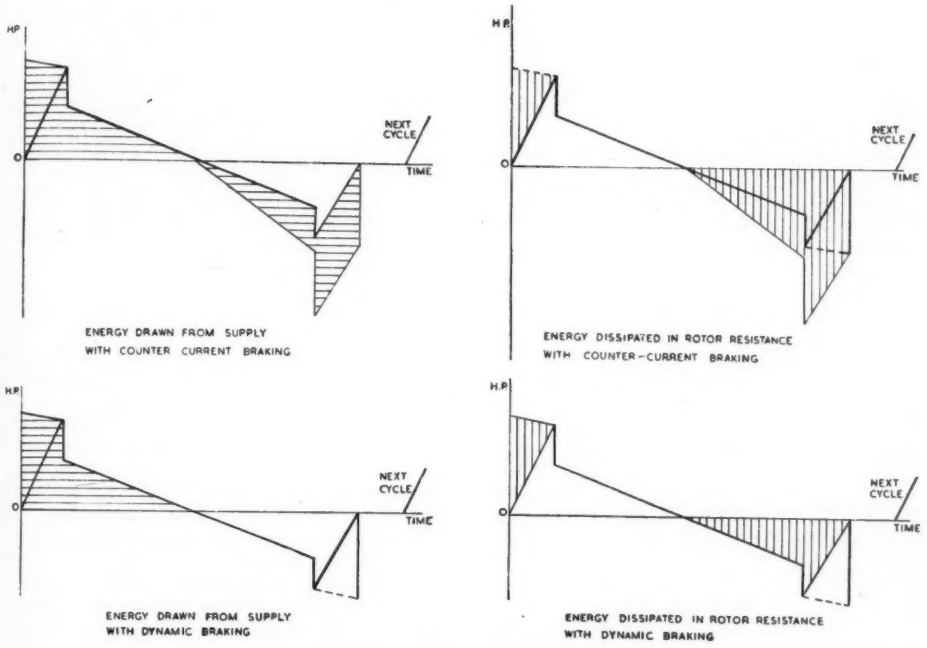

H.P.
NEXT CYCLE
TIME
O
ENERGY DRAWN FROM SUPPLY WITH COUNTER CURRENT BRAKING
ENERGY DISSIPATED IN ROTOR RESISTANCE WITH COUNTER-CURRENT BRAKING
ENERGY DRAWN FROM SUPPLY WITH DYNAMIC BRAKING
ENERGY DISSIPATED IN ROTOR RESISTANCE WITH DYNAMIC BRAKING

Fig. 5.—Energy Diagrams.

braking. The remarkable increase in operational efficiency accruing from the introduction of dynamic braking is readily apparent from the diagrams.

Various systems of dynamic braking have been fitted to a.c. winders. In the early days of the application both uncompensated and compensated forms were developed by different manufacturers but only the latter are employed to-day. (Uncompensated systems with constant excitation have been used occasionally on winders since 1915 with limited success, but the main dynamic braking development commenced after 1930.) The excitation may be applied in various ways to the stator, either by connecting two phases in parallel and connecting the d.c. source across these two phases and the remaining one in series, or across two phases in series with the third not used, or as indicated in Fig. 4. Braking power is related to excitation current, rotor resistance, and speed and the effective braking is varied by alteration in one or more of these factors. In dynamic braking schemes where excitation and resistance are co-ordinated, and a function related to speed is not taken into account, uncompensated control results. The unsatisfactory performance arising from the use of such a method lies in the fact that (*a*) for a given speed there is a critical value of external rotor resistance below which braking torque is reduced instead of increased and (*b*) there is a rapid loss of braking power with heavy rotor currents, caused by the demagnetizing effect of the rotor ampere-turns and the non-linear nature of the open-circuit characteristic.

An excitation system which automatically increases the excitation to off-set the effect of rotor current is the fundamental requirement of a compensated braking system and the characteristic result is the maintenance of braking torque down to low speeds.

The scheme indicated in Fig. 4 was the original compensated scheme and is still being employed at the present day. Fundamentally the d.c. excitation is derived from two sources. Firstly, constant excitation obtained from a static transformer and rectifier is applied to one stator phase. Secondly, variable excitation from a series transformer in the rotor circuit *via* a metal rectifier is applied to the other two stator

phases connected in series. The constant excitation represents only a small power demand on the supply, the majority of the electrical power for braking being derived from the kinetic and potential energy of the overhauling load itself.

In another dynamic braking scheme the demagnetizing effect of the rotor ampere-turns is compensated by increasing the d.c. excitation applied to two stator phases in series from an exciter as the speed increases. A further system introduces torque control and the rotor resistance is made to automatically adjust itself to the selected torque and excitation. Developments are still proceeding in this field, but it can be said that dynamic braking may be regarded as an integral part of all a.c. winders above about 400 h.p. In recent years it has become standard practice to arrange the electrical control circuits so that dynamic braking remains available in the event of an emergency trip—*i.e.*, should mechanical braking inadvertently fail, electrical braking can be used.

Driver's Control Equipment

In the period between 1930 and 1940 attention was turned to the control equipment used by the driver with a view to improving the arrangement and reducing fatigue. From the early days of electric winders many of the controls resembled those which are still to be found on steam winders installed some 50 years ago, the driver either standing or being seated on a high chair. Since electrical equipment required much smaller operating effort than the valve gear etc. for steam winders, desk type controls were designed and installed. Apart from incorporating the power, brake, and clutch levers, instruments, and indicating lamps, control desks were designed to accommodate the shaft signalling windows and miniature-type depth indicators.

1940–45

During the years of the second World War little progress was made in the field of the mine winder, though many techniques and analytical methods which were developed for military purposes were later used or adapted for peaceful objectives. After 1945 an era of electric winder installations commenced on a scale not previously experienced. Particularly large equipments were needed by the South African mines and the availability of dynamic braking, coupled with the lower capital cost of the a.c. winder, made this type of installation economical compared with the Ward Leonard which would have been installed prior to the War. The size of winder became so large, however, that twin a.c. motors had to be adopted from transport and

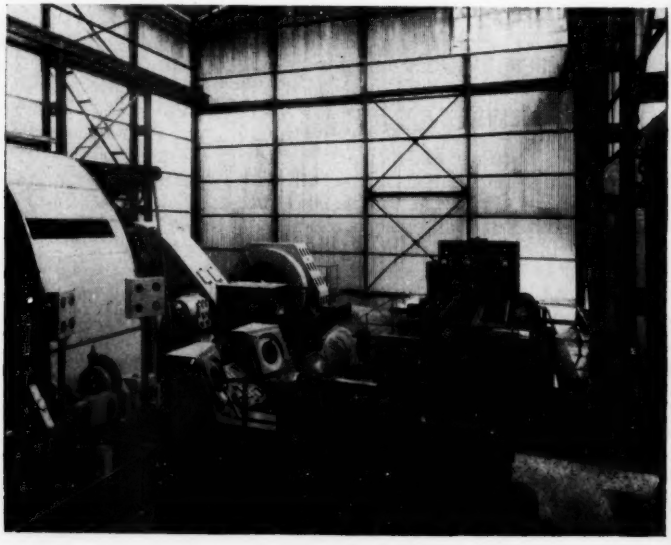


Fig. 6.—Twin A.C. Winder Drive at a South African Gold Mine.

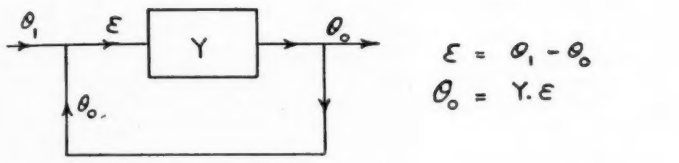


Fig. 7.

BLOCK DIAGRAM OF SIMPLE CLOSED LOOP SCHEME

gearing considerations. At the present time 6,000-h.p., R.M.S., twin a.c. winders are under construction. Fig. 6 shows a 4,040-h.p. R.M.S. 375-r.p.m. 6,600-V., three-phase, 50 cycles twin a.c. winder, with twin liquid controllers, installed in South Africa.

Closed-Loop Control

Up to this point the controls which have been considered have all been what are called open loop—that is, there is no compensation in, say, voltage or speed for external disturbances. If the voltage falls due to load then the driver would have to increase his setting to compensate.

The main advance in electric winders since 1945 has been the adoption of what are termed closed-loop or self-regulating controls. Though the principles of such servo systems were known for some time before the war two factors had limited their application. First, the mathematical methods for analysing the problems were not sufficiently well known or understood and, secondly, the amplifiers which are essential to the accurate performance of any closed-loop system had not been developed pre-1939.

Closed-loop controls have now been applied to all types of electric winder both on the electrical and mechanical sides and it is in no small measure due to these developments that modern winders perform accurately and reliably with the minimum of adjustment.

A closed-loop system is one in which a controlled quantity is compared with a reference quantity and the difference or error is used to cause the controlled quantity to become equal (or close) to the reference quantity. A block diagram of such a system is shown in Fig. 7. The quantity Y in the block is termed the loop transfer function and incorporates amplification and time delays. The response of a system to a change in the input quantity θ_1 may be stable or unstable, depending upon the loop transfer function Y.

In a stable system a steady value of the output quantity may be obtained for each value of the input quantity. A change in the latter may cause the output quantity to overshoot the desired value, but further oscillations are heavily damped. The system may also be such that no overshoot occurs but the response, though stable, may be too sluggish for practical application.

Of the many examples of closed-loop control as applied to electric winders one is shown in Fig. 8, which relates to a Ward Leonard equipment. This example shows the use of a pilot and control exciter to provide the facilities of smooth acceleration and accurate speed control of the winder motor. It is interesting to compare it with Fig. 2, yet despite the difference the scheme of Fig. 8 has already been changed to improve the performance, and reliability, by the use of static magnetic amplifiers instead of rotory exciters.

Trend towards Static Equipment

Converter-Fed Winders.—While most of the closed-loop control schemes applied to winders between the years 1945 to 1950 incorporated rotary amplifiers such as the amplidyne, magnavolt, or tuned exciter, metadyne or rototrol, progress has been made in recent years towards the replacement of such rotary equipment by the equivalent static amplifier. Transistors and magnetic amplifiers have now reached the reliability in service and consistency in performance required for mine-winder control.

The change from rotary to static equipment has not been confined to the control field alone. For many years the possibility of using mercury-arc converters in place of Ward Leonard motor-generator sets had been realized, but it is only within the last three years that this type of equipment has been incorporated on mine winders in Great Britain. The delay in the introduction of

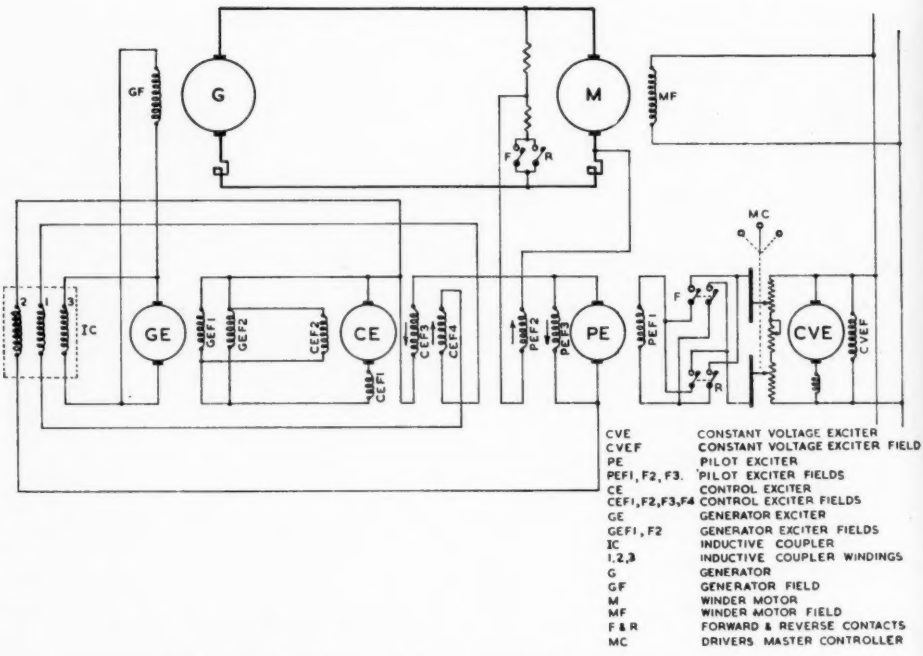


Fig. 8.—Ward-Leonard System with Closed-Loop Control.

converter control may partly be accounted for by the necessity of establishing reliable design techniques relating to grid-controlled mercury-arc converters (principally perfecting the system of inversion whereby power may be fed back to the supply from a regenerating load with a single MAC equipment).

Mercury-arc equipment has now been established as a reliable form of power conversion for mine winders and with the inherent characteristics of a d.c. motor for economic speed control, the converter-fed winder can be considered as an alternative to the motor-generator set in the Ward Leonard system. Three basic facts must be borne in mind when considering the application of converters to reversing drives :—

(*a*) Current can only flow in one direction.

(*b*) To supply d.c. power (rectification), the converter voltage must be greater than and oppose the machine back e.m.f.

(*c*) To accept d.c. power (inversion) the converter voltage must be less than and oppose the back e.m.f. of the machine acting as a generator.

The photograph of Fig. 9 shows a typical pumpless steel tank unit used in mining applications.

Supervisory Manual and Automatic Winding, Remote Control.—There is no doubt that the increased capital cost of installing an automatic mine winder has deterred many mining engineers from taking this step. This is particularly so since a skilled driver is still required to be in attendance. However, with the increasing need to maintain winding efficiency, complete safety of operation, and to economize on the use of man power, automatic equipment is often required for the main duty. A form of automatic control which is termed "supervisory manual" provides automatic acceleration and automatic initiation of retardation, but with this control the driver still has to bring the conveyance into the landing position by applying the brakes and controlling the power to the winder. On skip winders one man is usually in charge of the loading arrangements and so it would appear logical to control the skip completely by means of push buttons from the loading position.

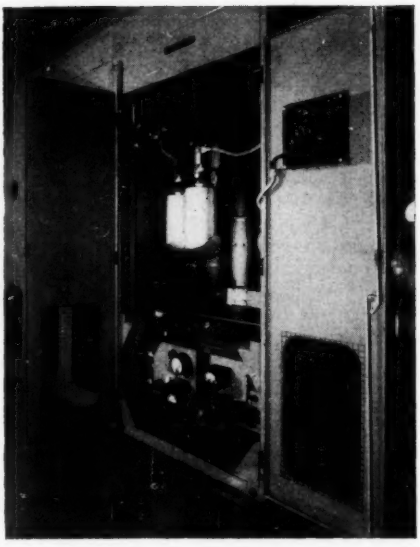


Fig. 9.—Mercury-Arc Converter.

One of the inherent features of the Ward Leonard winder is that by the use of cam gear or equivalent means the speed of the winder can be made to conform to a predetermined speed-time cycle, within practical limits. Even with the conventional Ward Leonard system without closed-loop control such conformity was approached and retardation could be enforced independent of the driver. This property of the Ward Leonard equipment is solely due to the d.c. machine characteristics, which are eminently suitable for speed control. All British manufacturers have now adopted closed-loop control for both Ward Leonard and converter-fed winders. The inherent single-slot control obtained with Ward Leonard winders and the advantages of readily achieved supervisory manual control with this system were attractive.

About 1950 British mining electrical and manufacturers' engineers turned their attention to the development of supervisory manual control schemes for a.c. winders. The problems were approached in various ways but all had the same objects—namely, those of increased safety of operation and increased output for reduced driver fatigue. Such supervisory manual control schemes for a.c. winders necessarily involve the use of closed-loop control features.

With this form of control the wind is initiated by the driver but the supervisory equipment keeps it to a prescribed cycle.

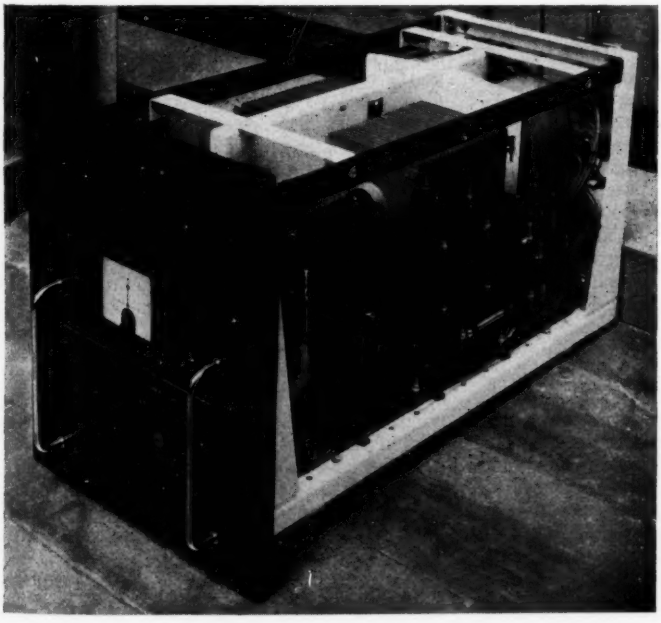


Fig. 10.—Magnetic Amplifier Chassis.

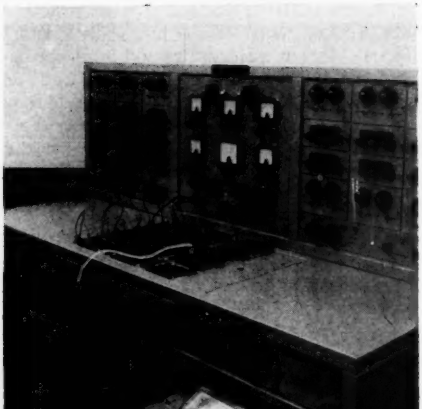


Fig. 11.—Analogue Computer for Winding Problems.

The driver is, however, free to operate the winder within the limitations imposed by the control—the driver completely taking charge only to apply the brakes to stop the winder.

One of the differences between the supervisory manual and the orthodox a.c. winder is that operation under both power and electrical braking is obtained in the same slot with supervisory control. Movement of the driver's lever *away from* neutral always produces increase of speed and movement *towards* neutral always gives reduction of speed, by the automatic use of dynamic braking if necessary. Nevertheless, the a.c. induction motor which operates on fixed voltage and frequency does not possess characteristics which are ideally suited to supervisory winder control and the instances when such features can be justified from an economic and operational standpoint are restricted.

The load torque variations during the different duty cycles on an a.c. winder may be such that control by purely electrical means becomes impossible and in such circumstances supervisory manual winding is not practicable unless electrical control of the mechanical brakes is introduced. In this event, owing to commercial and technical considerations, it is preferable to adopt Ward Leonard or converter-fed control if supervisory winding is thought essential. In general it may be said that supervisory manual a.c. winders should be confined to fixed-duty installations when it is possible to achieve cyclic manual winding within reasonable limits and winding to a predetermined duty cycle. For multi-duty a.c. winders it is desirable that orthodox manual control be used, except that automatic operation is practicable for the principal raising duty in skip installations.

Automation in the mining field is increasing year by year, but coincident with this growth is the demand for higher technical ability and maintenance standards on the part of the operators at the mine. Great progress has been made in the simplification of automatic winder control equipment, but nevertheless, relatively complicated control schemes must still be used in order to fulfil the strict performance requirements.

The type of winder and the maximum winding speed have a considerable bearing on the system which may be adopted for automatic winding. Single-level fixed-load skip winders of the friction type represent the most simple duty for automatic operation and for these equipments the a.c. or converter-fed winder is suitable. High-speed multi-duty cage winders operating to various levels are only practicable with Ward Leonard control if automatic operation is required with close decking accuracy.

The ancillary equipment which is essential to the operation of an automatic winder has also improved in the last ten years; as an example the ultimate stopping switches may be cited. Instead of using shunt-type switches operated by mechanical interference of the conveyance with an arm on the switch magnetic switches are now adopted. These induction pattern switches are used where the conveyance moves in fixed guides, but, when rope guides are in service, magnetic switches give place to photo-electric relays, particularly at intermediate levels.

A type of control which may be considered to be an intermediate stage between manual and automatic has been adopted on some winders which have been installed in the United Kingdom. In this system the duties of driver and banksman have been combined, control of the winder, shaft gates, and mine car handling equipment being in the hands of a driver/banksman situated at a remote bank control desk fitted with a Selsyn-driven depth indicator. This type of control is equally applicable to skip installations. With

remote control special problems are introduced on both the electrical speed control and mechanical brake control systems, but those in relation to speed control are capable of ready solution when the basic scheme employs closed-loop features. Further development is required in relation to remote mechanical brake control in order to achieve linear operation.

A category of remote control which may also be considered as a form of automatic control has been adopted on a number of equipments in Europe and the North American continent. Under this system of operation the winder is controlled from the conveyance by means of push-buttons in a similar manner to those used on passenger lifts. Trailing cable suspended from the conveyance has been used on some of these installations and a carrier-wave system adopted on others. Radio control has also been used as a means of sending pulses from the conveyance transmitter to a receiver mounted at the top of the shaft.

Conclusion

In a world which is hungry for its natural mineral wealth increased and more efficient production, greater safety and reliability, and reduced costs will undoubtedly remain the key-notes of the mining industry. Already considerable advantages are being derived from the use of automatic control and it is inevitable that a more widespread use will be made of this type of operation. Many of the persons required to maintain production with purely manual equipments will thereby be released for other work.

Coupled with the extension of automatic winding, and continuing the trend towards static equipment, solid-state devices and static switching must gradually take their place in winder controls. Quite rightly safe operation has been regarded as of paramount importance, particularly since the lives of men are involved, but in this age not a day passes without the safe keeping of hundreds of people being dependent on the correct functioning of miniature apparatus. Maintenance and servicing such equipment will demand special skill on the part of mine staff, but, by the manufacture of control units as plug-in assemblies, replacement parts may be readily fitted to enable winding operations to continue. This principle of packaged units has already been established in many fields and its extension to control components, depending upon identical operating characteristics to suit special control schemes, is rapidly becoming a practical proposition with improvement in manufacturing techniques and test facilities. The photograph shown in Fig. 10 shows the adequate monitoring facilities available in a magnetic amplifier chassis, while Fig. 11 illustrates an analogue computer used to assist in the mathematical analysis of mine winding problems.

The introduction of television to the mining field has already been made, not so much for direct control but as a means for enabling an operator to see the progress of events at a distant point. At one particular mine closed-circuit television allows the operator to see the skip discharging, note correct closure of the skip doors, and control the transfer of material into the storage bin on the surface. While it is not expected that television control will be applied on a large scale to mining work, there are grounds for believing that by its installation labour costs can be reduced and more efficient production obtained.

It must be concluded that the advance is always in detail, but that the sum total combines to make present-day equipments vastly superior in technique, efficiency, and operating performances. We may be sure that the next 50 years will provide as fruitful and significant an advance as the last half century.

Acknowledgment.—The authors wish to thank the English Electric Co., Ltd., for giving permission for the publication of this article.

The Auchengeich Pit Disaster

A note from **Gandy, Ltd.,** of Wheatland Works, Wallasey, Cheshire, refers to Press reports of the inquiry into the disaster at the Auchengeich colliery, at which it was stated that the cause of this, resulting in the death of 47 miners, was due to a sub-standard belt supplied by a Birkenhead firm. The general inference, it is thought, is that Gandy's were the manufacturers, which is untrue. The company points out that every belt leaving their factory undergoes the strictest test before installation and they ask our co-operation in making a bold announcement stating that the firm were not the manufacturers of the belting supplied to the National Coal Board.

The Present State of the Witwatersrand Controversy

C. F. Davidson[1]

A review of recent research

Much has been written in support of a placer origin for the banket ores of the Witwatersrand and Blind River in the last two years, since the writer published the latest of a series of papers discrediting this popular hypothesis. Some ten dissertations read to learned societies in South Africa, a weighty memoir or two issued by the Berlin Academy, several lengthy reports contributed to a recent international conference sponsored by United Nations, a few reviews in German, Finnish, and Russian periodicals, and a dozen or more long letters contributed to British and American journals, all combine to present arguments in favour of the syngenetic origin of the ores and to refute the evidence advanced in support of epigenetic mineralization. From this spate of publications some important new facts can now be culled, and it is therefore appropriate to examine the disputations and see what progress has been made. This analysis is the more necessary in that conclusions on the hydrothermal genesis of these uranium ores have been accepted in recent text-books and thus merit a vociferous denunciation if indeed they are in error. Of whether this is so or not the reader is the judge.

Among the several categories of recent studies it is appropriate to consider the testimony of age determinations; conclusions reached from comparison with modern placers; geochemical evidence; deductions from mineragraphic research; and geological considerations. It is accepted throughout this review that the uranium, the sulphides, and the gold present in these ores are cogenetic. The evidence already adduced for this fundamental tenet (Davidson, 1957)[2] is so strong that it admits no denial and postulates to the contrary do not merit serious consideration.

[1] Professor of Geology in the University of St. Andrews.

[2] A list of references will appear at the end of this article.

The Testimony of Age Determinations

The earliest geochronological studies on Witwatersrand uraninite, reported by the writer in 1953, gave a 207 : 206 age at about 2000 m.y., with discordant 206 : 238 and 207 : 235 ages respectively of 1300 m.y. and 1600 m.y. The isotopic analyses were made in triplicate by the laboratories of A.E.R.E. (Harwell), Columbia University, and Toronto University, the three sets of results showing excellent agreement. Discordance was finally attributed to three possible factors, namely: (*a*) re-working into two or more generations, proven by the local occurrence of uraninite of much younger date; (*b*) the problematical presence within the uraninite of old radiogenic lead; and (*c*) radon leakage, this occurring to a minor extent only. It was concluded (Davidson, 1957) that if old radiogenic lead is absent the uraninite must be as old as 2000 m.y., but if old radiogenic is present in the lattice of the mineral, the age could be much younger. Including determinations executed by Louw (1955) in South Africa, the 10 "best" results yet reported, most acceptable because they were executed on the purest samples, show a range in 207 : 206 ages of from 1900 m.y. to 2230 m.y., with an average of 2069 $\pm$ 150 m.y.

On the basis of these age determinations, coupled with an acceptance of the postulate of hydrothermal mineralization, the writer concluded in 1953 that "the Witwatersrand sedimentary series is much older than hitherto believed." In 1955 he correlated the mineralization with the Limpopo granitization (2080 $\pm$ 40 m.y.); and in 1957, in expansion of a hypothesis advanced four years earlier, he concluded that "the mineralization apparently dates from the period of post-Transvaal earth movements which gave rise to the Vredefort and other domes, accompanied by the Bushveld granites, alkalic plutons, and nepheline-syenite dykes." Recent geochronological

studies by South African scientists have confirmed these predictions by the discovery of many different but convergent lines of new evidence, the acceptance of which demands a drastic revision of pre-existing concepts on the geology of South Africa.

For the benefit of readers unacquainted with Transvaal stratigraphy the relevant part of the geological succession is summarized in Table 1.

It has been widely held in South Africa that these sediments are of late Proterozoic age and that the antiquity of the Witwatersrand uraninite provided proof of its derivation as detritus from ancient granites and schists. These arguments are now untenable in the light of the following new data.

First : Geochronological studies by Nicolaysen, de Villiers, Burger, and Strelow (1959), employing the rubidium : strontium method on micas from Bushveld granites, have given ages of 1950 $\pm$ 50 m.y., 1890 $\pm$ 60 m.y., and 1690 $\pm$ 90 m.y. for this intrusive complex. A fourth assay on the biotite of a Bushveld biotite-pyroxenite gives the value 2050 $\pm$ 50 m.y. The lowest of these results is considered by the authors to be inadmissible, and it is concluded that both the basic and acid plutonic phases of the Bushveld were emplaced within the time interval 1830–2100 m.y. A date of 1950 $\pm$ 50 m.y. is preferred.

Second : A similar investigation by Schreiner (1958), utilizing the same method for nine determinations on the feldspar, biotite, and whole rock of the Red Granite of the Bushveld Complex, gives a comparable age of 1920 $\pm$ 110 m.y.

Third : Two specimens of galena from the Bushveld Complex in the Potgietersrust area have been analysed isotopically by Toronto University and are reported by Holmes and Cahen (1957) to possess conventional ages of 1910 and 2010 m.y. A third sample from Potgietersrust, analysed by Columbia University, is dated at 2110 m.y. ; and a fourth determination by the latter laboratory, on galena from the Transvaal System in the Pretoria district, gives a conventional age of 2140 m.y. These lead ores were believed by Holmes and Cahen (1957, p. 77) to be representatives of an old mineralization re-worked from the underlying Basement. In the light of present knowledge they are clearly co-eval with the Bushveld igneous rocks.

Fourth : Analyses by Nicolaysen and others (1959) of a larger group of galenas from the Transvaal System suggest a wider pattern of variation, but all the galenas in the Transvaal Dolomite along the south-western limb of the Bushveld Complex agree well in age, at around 2000 m.y., contemporary with the rubidium : strontium dating of the granites.

Fifth : These authors have also shown that uranium : lead age measurements on the zircons from a granite at Ottensville, Central Bushveld, give

Table 1

Bushveld Igneous Complex			Intrusions of granite, norite, diabase, etc.
Transvaal System		Pretoria Series	Shale and sandstone. Andesite lava.
		Dolomite Series	Dolomitic limestone and chert.
		Black Reef Series	Sandstone and conglomerate.
		Unconformity	
Ventersdorp System			Mainly volcanics, with a basal conglomerate.
		Unconformity	
Witwatersrand System	Upper Division	Kimberley-Elsburg Series	Sandstone, with two horizons of conglomerate. Shale at base.
		Main-Bird Series	Sandstone and grit, with occasional conglomerates. Amygdaloidal lava near the top.
	Lower Division	Jeppestown Series	Mainly shale with subordinate sandstone. Band of amygdaloid.
		Government Reef Series	Alternations of shale and sandstone, with bands of grit, conglomerate, and tillite.
		Hospital Hill Series	Sandstone and ferruginous shale.
		Unconformity	
Dominion Reef System		Upper Volcanic Division	Quartz-porphyry, rhyolite and andesite.
		Lower Sedimentary Division	Sandstone and grit, with basal conglomerate.
		Unconformity	
		" Archaean " granites and schists	

a value of 1870 ± 100 m.y., in reasonable agreement with the determination of 1950 m.y. obtained by rubidium : strontium assays on the micas of the same granite.

Sixth : A radioactive heavy-mineral concentrate (titanite, zircon, monazite) from Byerley's claims at Beitbridge (migmatites of the Limpopo granitization) has been analysed at Toronto University by the complete lead method, giving results in excellent agreement at 1940 ± 60 m.y. Potassium : argon determinations on microcline from the same rock by Wasserberg and Hayden (*in* Holmes and Cahen, 1957) give a value of 1660 m.y., which after correction for a possible 23% average argon loss from pegmatitic feldspar (Davidson, 1960*a*) is equivalent to 2041 m.y. It is thus apparent that the Limpopo granitization and the Bushveld granitization are essentially contemporary. Consequently the radioactive minerals present in the Witwatersrand reefs cannot be detrital derivatives of the Limpopo granites, as assumed by Liebenberg (1956) and by Holmes and Cahen (1957).

Seventh : A complete isotopic assay of uranothorianite from the carbonatite complex of Palabora (Phalaborwa) gives an age of 2060 m.y. (Russell and others, 1954), with the several ratios in good agreement. The radioactive carbonatite and associated syenites are thus contemporary with the Bushveld granitization and with the banket uraninite. (Other alkali syenites in the Transvaal may be younger : Schreiner and Van Niekerk (1959) have dated the Pilanesberg intrusion at 1290 ± 180 m.y.)

Eighth : Six age determinations by Nicolaysen and others (1959) on samples of monazite from the Bushveld Complex give 207 : 206 ratios which are consistent, in the range from 1970 ± 70 m.y. to 2050 ± 110 m.y., with 207 : 235 and 206 : 238 ratios in very good agreement. The thorium age (208 : 232) is discordant at 390 m.y., the reason for this discrepancy being unknown.

Ninth : An investigation by Mendelssohn, Burger, Nicolaysen, and de Villiers (1958) on a monazite occurring in the gold-uranium ores of the Nigel Reef at Sub-Nigel mine, Witwatersrand, gives 207 : 206, 207 : 235, 206 : 238, and 208 : 232 ages *all* in excellent agreement within the range from 2010 ± 50 m.y. to 2180 ± 30 m.y. The monazite is described as being in well-defined crystals up to 3 mm. in size, its faces showing brilliant lustre with no signs of rounding or attrition. It is developed in a matrix of chlorite and sericite, as a complete replacement along 21 feet of the reef, the thickness of the replaced bed being between 1 in. and 6 in. Quartz pebbles are almost completely replaced by monazite, chlorite, and sericite, together with rarer cubes and irregular grains of pyrite, residual ilmenite rimmed by leucoxene [possibly brannerite], and rather coarse gold. A veinlet of monazite passes into the shale at right angles to the contact. According to Liebenberg (1956) this monazite is accompanied by abundant uraninite identical to the uraninite elsewhere in the bankets. When first recorded by Mendelssohn (1933) the monazite was described as "hydrothermal." To-day it is claimed to be "authigenic," despite the absence of any known occurrence of authigenic monazite in a sedimentary rock. Its contemporaneity with the Bushveld monazite demonstrates unequivocally that it represents an epigenetic mineralization of the Witwatersrand reefs which occurred in Bushveld times.

In this long sequence of age determinations the uraninite was dated first and the other determinations followed, the latter all reported by workers unsympathetic to the concept that the bankets had been mineralized epigenetically. No grounds therefore exist for any contention that there has been a subjective choice of data. The concordance of results is fuller than in any other geochronological study of a comparable character recorded either in Western or in Russian literature. On the basis of the hydrothermal theory it was forecast that the Witwatersrand formation would be found to be much older than hitherto realized, that the uraninite mineralization would turn out to be co-eval with the Bushveld magmatism, and that the Bushveld and Limpopo granitizations would prove to be contemporary. That these forecasts have been confirmed is testimony to the soundness of the theoretical foundation on which they were based.

All these researches, however, are ignored in the latest publication of Ramdohr (1958*a*), who states repeatedly that the uraninite mineralization of the Dominion Reef is around 3000 m.y. old, whilst that of the upper part of the Witwatersrand Series dates from 1800 m.y. It is claimed that at both horizons the uraninite is of placer origin. Such suppositions introduce the absurdities (*a*) that the uraninite found its way into the upper reefs, as detritus, long after these reefs were deposited ; and (*b*) that, although uraninite does not accumulate in placer deposits to-day, *twice* in the history of the South African formations there were formed very rich placer deposits of gold, uraninite, and pyrite, successively derived as detritus from two different cycles of bedrock mineralization separated by a time interval of 1200 m.y. No comment is needed to expose the incredibility of these remarkable hypotheses.

In another contribution de Villiers and others (1958) suggest that although the Witwatersrand uraninite is apparently contemporary with the Bushveld magmatism and with the hydrothermal monazite of the Sub-Nigel reef, this coincidence in ages is no more than fortuitous. It is claimed that the age determined on the uraninite grains is not their true age, but indicates a notional period when pre-existing uraninite grains were purged of their lead by re-working. To avoid a conflict with the mineragraphic supporters of the placer hypothesis it is maintained that throughout this chemical

rejuvenation the minute ovoids and spheroids of uraninite preserved their pristine morphology without any gross change of form. This new hypothesis is based on the abnormally old isotopic composition of galenas found in veins in the vicinity of the bankets. de Villiers, quoting the writer, indicates that the radiogenic component of these galena leads can theoretically have arisen in one of two ways. *Either* : (1) it may have accreted during the re-working or re-crystallization of uraninite in the banket reefs themselves, on one or more occasions, after the uraninite was initially emplaced within the conglomerates ; *or* (2) it may have been generated from uranium in a " depth-source " from which the mineralization in the conglomerates emanated if a hydrothermal mineralization is postulated. On the first assumption calculations show that the initial uraninite must have been *more than* 2470 m.y. old. It could therefore have been derived, as alluvial detritus, from the Shamwaian basement (dated at around 2600 m.y.) or from an earlier formation.

Let us consider the first conception, which supports a placer hypothesis. That two or more generations of uraninite occur in the Witwatersrand reefs was first shown by Bowie and the writer (1951) ; and a specimen of regenerated uraninite, specially picked out under the ore microscope as being typical of late re-worked mineral, has been proved by Horne (1957) to be as recent as Mesozoic in age. But there is little agreement on the extent of this re-working. Although Liebenberg notes that in the Bird Reefs secondary uraninite may often be the major uraniferous constituent and that it is present elsewhere in important amounts, the writer maintains that most of this reputedly regenerated uranium mineralization, which replaces quartz, pyrite, sphalerite, and other minerals, is really of epigenetic origin and that re-worked uraninite occurs only subordinately. Contrariwise, Ramdohr has repeatedly and emphatically claimed that secondary uraninite, if present at all, forms no more than " a *very* small part in quantity and distribution." Re-working has already been taken account of by Tugarinov (1957), Gerling (1958), Horne (1957), and others in attempts to explain the discordant pattern of the age determinations carried out on Witwatersrand ores ; but significantly the regenerated mineral shows precisely the same pattern of discordancy, a pattern which Horne has explained as being due to the incorporation of radiogenic lead into the lattice of the secondary uraninite at the time of its neoformation. Thus the existence of *small-scale* re-working is not in dispute. Extensive chemical rejuvenation of the Witwatersrand uraninites, on a scale sufficient to provide galena veins in the country rock, is however ruled out by the following considerations.

First, it has been shown by the writer (1957) that it is possible to prepare from a single localized sample of reef, using simple physical ore-dressing methods, two separate samples of galena differing in mean mass number of the lead by as much as 0·59. From this it follows that the individual occurrences of galena throughout a reef vary greatly in isotopic constitution and that on re-working the movement of the lead has been quite local, without widespread blending and without removal to form galena veins " emplaced in the vicinity of the conglomerates."

Second, it may be argued that this later minor re-working is irrelevant in consideration of a hypothetical major regeneration at the times of the Bushveld magmatism or Ventersdorp volcanism. Consider then the constitution of the bankets. Since the reefs contain chalcopyrite, blende, and other sulphides it can be concluded that part of the galena was emplaced, either syngenetically or epigenetically, at the same time as the other metals. There is an original lead component present in the galena of the reefs to-day which reflects this original mineralization. The hypothetical major regeneration, therefore, demands that the notionally detrital uraninite particles be stripped of their heritage of radiogenic lead, which is removed to form veins elsewhere, whilst at least an important part of the common lead in the same rock remains undisturbed. When the proponents of this hypothesis can demonstrate a form of metamorphism by which lead can be withdrawn from uraninite particles without it being extracted from adjacent particles of galena, then and not until then will their views command credence.

An interesting contradiction between the principal adherents of placerism derives from the hypothesis under consideration. Mineragraphic studies demonstrate that during the minor re-working to which the rounded uraninite grains have undoubtedly been subjected, the spheroidal form is destroyed and the secondary pitchblende is deposited within the banket as veinlets. To accept that the rounded particles could

have retained their supposedly detrital shapes throughout a period of major metamorphism, during which they were purged of their lead, thus imposes a breaking strain on credulity. This re-working hypothesis is, therefore, fundamentally incompatible with the conclusions of the mineragraphic monographs which until now have furnished the principal argued support for syngenesis.

The alternative hypothesis, that the old lead came from a depth source, can be maintained if and only if it is accepted that this source was a more complicated one than a simple granite of Bushveld age, for a direct derivation from a Bushveld granite could not produce a galena-lead older than, say, 2000 m.y. As suggested by the writer in a previous paper (1957), the key to the mechanism of the Witwatersrand mineralization is to be found in the thorough study of Duhoux (1950) on the gold of Kilo-Moto, in which it is shown that the processes of formation of migmatic granite lead to a concentration and redistribution of metallic elements on an enormous scale, ahead of the front of granitization. It is believed that these mineralized emanations have travelled upwards and outwards through the sedimentary sequence where, considering the feldspathic nature of the rocks, the lead : uranium ratio is likely to have been higher than the crustal average. In their centrifugal progress from the Bushveld-age granitization which formed the culminating phase in the core of the Witwatersrand-Transvaal geosyncline, the emanations have taken up a secular excess of the old sedimentary lead present in the stratigraphical column, old lead derived from the denudation of rocks of Shamwaian (2600 m.y.) or earlier age. As a result, during the orogeny leads of three different kinds were formed : (*a*) Bushveld galena-lead, derived direct from the mantle and deposited where there was no contamination from older sources, as is found in the Bushveld Complex itself and in nearby veins in the Transvaal dolomite ; (*b*) mixed galena-lead, accompanying the gold-uranium mineralization of the Witwatersrand and associated lodes ; and (*c*) Shamwaian galena-lead, produced where the emanations were devoid of Bushveld lead, but were able to concentrate pre-Transvaal sedimentary lead into veins traversing Transvaal strata, as apparently happened in Cape Province. All this is no more than hypothesis—but, unlike the postulate previously considered, it is a hypothesis that fits the facts. It is a hypothesis agreeing with a recent generalization of Vinogradov : "*La comparaison de la composition isotopique du plomb de minerai et du plomb des roches encaissantes indique une liaison génétique du plomb du minerai avec le plomb des roches des étages inférieurs de structure.*"

If this conclusion is correct the formations towards the cores of the Witwatersrand and Huronian geosynclines should be, in whole or in part, slightly impoverished in lead. Recently, as discussed in more detail below, Fuller (1959*b*) and Pettijohn (1959) have respectively drawn attention to the anomalous chemistry of the Lower Witwatersrand and Lower Huronian shales, these rocks being identical in composition though without parallel elsewhere in the geochemical record. No information is available on the lead content of the Witwatersrand sediments, but the analyses of Cobalt argillites, two in number, show a tenor of 0·0004–0·0005% Pb. This figure is a third of the clarke of lead in the lithosphere and less than a quarter of the clarke in argillaceous rocks, of which 87 assays listed by Wedepohl (1956) show a range of 0·0015–0·0025% Pb. Further analyses are needed to demonstrate whether this apparent support for the writer's views is other than a fortuitous coincidence.

Circumstantial support may also be adduced from consideration of the world distribution of very old galenas. Curiously, with but few exceptions the known occurrences are all in gold deposits. From Southern Rhodesia no less than 19 isotopic assays of galena-lead with a model age in the range 2800–3100 m.y. (pre-Shamwaian) are on record, almost all from gold lodes. At Rosetta, near Barberton in the Transvaal, the galena from a gold lode has a conventional age of 3350 m.y. ; and another old galena-lead, in the range 3310–3430 m.y., comes from auriferous quartz veins cutting sugary quartzites and sericite schists in the Bondo-Uele region of north-west Belgian Congo. In West Africa similar lodes cutting the schists of the Sula mountains in Sierra Leone bear galenas grouped around 2800–3100 m.y. (Holmes and Cahen, 1957) ; and again in North America the oldest lead minerals are found in auriferous quartz veins, with a model age in the range 2740–2900 m.y., in the Wind River age of Wyoming (Cannon, 1957). In Western Australia galenas from gold reefs are reported to be dated at 2760 m.y. (Russell and others, 1954) ; and similar conventional dating of galena from

the Kolar gold-field of Mysore gives 2450 m.y. (Holmes, 1955). Clearly there is nothing at all unusual in old galenas being associated with hydrothermal gold deposits. Whilst it is an open question whether the country rock of these veins is still more ancient or whether (as maintained here) the mineralization has been generated ahead of a front of granitization, it should be recognized that if the former view is maintained the Fig Tree Series (Swaziland System) of shales, cherts, banded ironstones, and coarse clastic sediments which form the environment of the Rosetta lode must have an age in excess of 3350 m.y., and the underlying Onderwacht lavas must be still older. The granites represented by boulders in the basal conglomerates of the succeeding Moodie's system are claimed to be of even greater age than the Onderwacht volcanics (Visser, 1956). Thus if the galena of the Rosetta lode is not regenerated, it follows that in South Africa there are rocks exposed whose age is quite close to that of the primeval crust of the earth !

That re-working or regeneration of ore deposits is of much wider occurrence than generally believed has lately been demonstrated by the writer (1960*b*) in a note on the " Hercynian " uranium deposits of Central and Western Europe. Although these mineralizations are genetically connected with late Carboniferous granites, they are shown to have been re-worked again and again at various periods up to late Cretaceous times.[1] In such ore deposits, however, the oldest uraninites recognized are, as one would expect, contemporary with the igneous activity. It is the same story in the Witwatersrand. Determinations by the Rb/Sr method on the micas and the feldspars of the Bushveld granites and associated rocks, by the Pb/alpha method on zircons from the granites, by the U/Pb (isotopic) method on heavy mineral concentrates from migmatite, by K/A determinations on granitic feldspar, by model ages on galenas, and by complete isotopic assays of granitic monazite and of monazite epigenetically replacing a gold reef—all, without exception, give ages of the same general order as does the old uraninite in the auriferous bankets. That the uraninite is contemporaneous with the granitization brooks no denial. Rarely in the history of economic geology has such unequivocally factual support been forthcoming for a theory of ore genesis.

[1] Simultaneously, much the same conclusions have been arrived at by Vinogradov and others in studies of the ore deposits of Saxony (*Freiberger Forschungshefte*, C.57, p. 73, 1959).

Comparison with Modern Placers

The strongest argument against the placer origin of the banket-type mineralization is the extreme rarity of uraninite in modern placers. When we consider that the Witwatersrand and Blind River conglomerates are now yielding upwards of 20,000 tons of uranium annually, surely it is remarkable (if these formations are fossil placers) that in the greatest prospecting campaign which the world has ever seen, not a pound of detrital uraninite has ever been marketed from any present-day gravel ? When we bear in mind that the estimated reserves of the banket formations amount to some 700,000 tons of urania, is it not astonishing that not a single alluvial deposit meriting exploitation as uranium ore has ever been found ? This argument has already been elaborated elsewhere (Davidson : 1953, 1957) and it need not be repeated in detail ; but since the validity of its premises has lately been questioned it becomes necessary to review the contrary evidence.

In this connexion Roscoe and Steacy (1958) have enumerated as the first line of " strong argument in favour of a detrital origin of the Blind River uraninite " the fact that " uraninite has been found in modern placers." Bosazza (1959) claims to have found uraninite " both in large boulders of the mineral and in small grains " in the Tambani alluvials of Nyasaland ; and Ramdohr (1958) reports a discovery of uraninite in the sands of the River Indus. Liebenberg (1958) also clings to these straws to support his views. He writes :—

> Arguments against the survival of uraninite as a placer mineral, the idea being claimed as a " first principle," have also been raised against a placer origin for the conglomerates : both its chemical instability and proneness to comminution were advanced to indicate the non-survival of uraninite as a placer mineral. The non-survival of uraninite is, however, unfounded as evidence of the survival of uraninite, even in modern placers, is slowly accumulating. According to a verbal communication from Mr. H. R. Steacy, uraninite has been found in other areas of Northern Canada in addition to the one described. In a private communication to Prof. J. Willemse of the University of Pretoria, Prof. Paul Ramdohr of the University of Heidelberg, Germany, stated that grains of uraninite have been traced in the sands of the Indus River, Punjab. India (*sic*), for a distance of more than 50 miles,

This is not surprising seeing that any mineral could survive as a placer mineral provided the prevailing conditions at the time of transportation and deposition were favourable.

No claim has ever been made that uraninite cannot exist as a placer mineral. It is merely asserted that it cannot survive the long transportation and natural milling which is a prerequisite to the formation of oligomictic conglomerates and quartzites. Indeed, the only well-documented account of detrital uraninite has been produced by the writer (1955), who has demonstrated that this mineral does not survive transportation for a few hundred yards along a pebble beach. It has also been shown (Davidson, 1953) that although placer uraninite is found only as freak occurrences, minerals of the uraninite-thorianite series become progressively more resistant to chemical decay with an increasing tenor of thorium, uranothorianite being not at all uncommon as a detrital species. In the light of these observations let us see what the placerist claims amount to.

First, consider the " detrital uraninite " reported by Steacy (1953), which has recently been referred to so many times. This came from " a radioactive black sand reputedly taken from a placer deposit in British Columbia," and was submitted by an American prospector to the Geological Survey of Canada. It is claimed to be the first unquestionable identification of uraninite as a detrital mineral. The uraninite grains are less than 0·2 mm. in diameter, mostly rounded but a few are euhedral, showing excellent development of the cube and possessing an almost brilliant lustre. Acceptance of this report as relevant to the Witwatersrand controversy must be condemned on two separate counts. Firstly the precise locality of the occurrence is not known. Consequently the local geology is not known and it is thus impossible to say whether it merely derives from bedrock mineralization nearby. The co-existence of rounded particles along with brilliant euhedral cubes suggests that there has been little transportation from the site of origin. Secondly, a placer of virtually the same mineralogical make-up as that described by Steacy, containing like the latter the very rare mineral association gold, platinum, cinnabar, and scheelite and like the latter occurring in a valley in British Columbia, has been described contemporaneously by Thompson (1954). In this instance, however, no uraninite is recorded but " thorianite is present in all screen sizes below 60 mesh . . . The mineral occurs in blackish grains from 50 microns to 150 microns in diameter. Many grains are rounded and others are almost perfect cubes. An X-ray powder photograph is in exact agreement with thorianite (a = 5·58 Å) from Balangoda, Ceylon. The mineral is probably the uranoan variety because the grains give a positive bead test." It would thus seem that, in the absence of any published physical constants for Steacy's critical detrital uraninite, there are grounds for suspicion that it is not uraninite at all, but uranothorianite.

Comparable ambiguities arise concerning the reputed detrital uraninite from the Tambani district of Nyasaland. The presence of relatively abundant uranothorianite in these alluvials was recorded by the writer in 1955; and although uraninite has since been found by Bosazza and others in the syenitic bedrock nearby, this mineral does not occur in any of the placer samples examined in Britain. The paragenesis of the uraninite suggests, however, that it is a thorium-rich variety and its occurrence (but not its long-term survival) in the adjacent alluvials would not therefore be surprising.

Ramdohr's occurrence of " uraninite " in the auriferous gravels of the River Indus has recently been described by his associate Zeschke (1959), who has examined what is obviously a collection of final clean-up concentrates from primitive gold-washings. These are derived from a stretch of 50 km. (possibly 100–250 km.) of the river course on the N.W. Frontier–Punjab boundary. In particle size the radioactive mineral ranges from 25 to 250 microns, occurring mainly in well-defined cubes, very rarely slightly rounded (" *nur ausnahmsweise erscheinen sie schwach gerundet* "). This is in strange contrast to the reputed *Gerölle* of the Witwatersrand; and a claim that the uraninite particles gradually become smaller on passing downstream cannot be reconciled with this idiomorphic habit. In fact, the bedrock sources of the mineralization are unknown and there is thus no evidence whatever of long-continued downstream survival. Apparently insufficient material has been available to permit separation of enough uraninite for chemical analysis or even for radiometric assay; and a bulk chemical analysis of 55 concentrates is suspect since the reported average value of 1·8% U_3O_8, 0·1% ThO_2, 1·8% Ce earths does not tally with a bulk mineralogical analysis of eight representative samples stated to average uraninite 0·9%,

monazite 4·0%, zircon 11·5% (and no other radioactives). The radioactive cubes may well be uraninite, as diagnosed; but no satisfactory evidence has been presented to show that they are other than aldanite or uranothorianite, which have been recorded from similar auriferous placers at a great many localities in Soviet Asia and in the Cordillera of North America. The zoned crystals figured by Ramdohr (1958*a*) are strongly suggestive of uranothorianite.

As yet another example of alluvial uraninite Zeschke refers to a placer on the Popovka river near Leningrad, which according to "verbal communications from Russian colleagues" yields heavy-mineral concentrates assaying 0·2% eU_3O_8 by radiometric analysis but only 0·02% U_3O_8 by chemical analysis. The difference is ascribed to leaching. Most astonishingly, it is not recognized that this relationship is an intrinsic feature of all radioactive placer deposits, the difference between the radiometric and chemical assays being due not to leaching or disequilibrium but to the presence of a large excess of thorium over uranium. There is thus no reason whatever to believe that the Popovka alluvials contain uraninite.

From experience in Russia, Alekseev and others (1957) record that detrital uraninite persists only in permafrost and that even with detrital titanates such as brannerite the range of transportation is usually no more than a few kilometres. Heinrich (1958) has noted that: "Most alleged detrital uraninite is uranothorianite." The published data are quite insufficient to show that the minerals described by Steacy, Bosazza, and Ramdohr are exceptions to these generalizations.

Nevertheless, in an attempt to uphold the alluvial origin of the Witwatersrand uraninite notwithstanding the rarity or absence of detrital uraninite to-day, Ramdohr (followed by others) has postulated that the South African mineral had at the time of its original deposition an unusual resistance to weathering and abrasion because of its extreme youth. It is maintained that whilst old uraninite may be unstable in placers, the mineral can readily survive when still very young and not weakened by radioactive decay. This claim is founded on the suppositions (*a*) that a young Tertiary uraninite from the granites of the Bergell Alps, with a brown-red translucency in thin splinters,[1] is refractory to decay; and (*b*) that the Witwatersrand mineral sometimes shows a supposedly abnormal octahedral parting notionally induced at the time of formation of the conglomerates. In refutation of these claims the writer (1957) has shown (*a*) that even under Alpine conditions the Bergell uraninite occurs heavily coated with alteration products and is manifestly far from refractory; and (*b*) that the rare octahedral parting supposedly diagnostic of detrital uraninite has already been observed in a pegmatitic occurrence of the mineral. It was added :—

> Some geological considerations likewise rule out Ramdohr's hypothesis . . . If the uraninite were derived as detritus from very young granites and pegmatites, then the emplacement of these igneous rocks in masses of truly vast size must have preceded the deposition of the earliest sediments by no more than a few million years. Such a concept is surely contrary to all ideas of geosynclinal development. And since the deposition of these 35,000 feet of sediments must have taken at least 20 million years [neglecting the period represented by the unconformities], during which period the uraninite would lose its refractoriness by ageing, one would expect the dominant mineralization to occur in the Lower Division (this, together with the Dominion Reef, supports two mines), rather than in the Upper Division (where, together with the Black Reef, some 90 mines are situated). Thus no support can be found for the idea of uraninite being refractory because of an extreme youth.

In recent publications Ramdohr (1958*ab*) has attempted at length to contemn these criticisms. He contradicts the above observations on the stratigraphical distribution of the uraninite with the statement that "According to the latest map of the Rand, three uranium mines occur in the Lower Witwatersrand and Dominion Reef, 22 in the Upper Witwatersrand and Black Reef—that is very different from 2 : 90!" This is pure sophistry, for he cannot but be well aware that the 2 : 90 ratio is based upon Liebenberg's paper (1956), republished in the semi-official work "Uranium in South Africa" (1957). He cannot but be well aware that there is no geological evidence at all for a period of granitization shortly pre-dating the bankets. Yet he goes on to enumerate various criteria for distinguishing young, detrital *uranpecherz* from hydrothermal pitchblende—cleavage, zonary structure, relics of idiomorphic habit—all of which, in the writer's view, are completely subjective and based on no scientific principle whatever. The so-called cleavage supposedly diagnostic solely of young alluvial uraninite has been recently figured from a pitchblende vein in the Erzgebirge (Oelsner, 1958, fig. 6).

[1] Not *Splittern* as Ramdohr quotes, but *Splitterchen* (Hirshi, 1925).

A further comparison between the bankets and modern placers has been made by Bosazza (1959), Nel (1958), and others in an effort to show that pyrite and other sulphides may readily survive as alluvial detritus, even under the harshest climatic conditions. The example which the former has chosen to demonstrate this is a singularly unilluminating ore. He refers to a report by Sir Albert Kitson on heavy concentrates from the Gold Coast, in which out of 639 samples studied pyrite was found 29 times and other sulphides much less frequently. But, making allowance for 53 of these samples which are crushed bedrock and not alluvials at all, the correct ratio for the Ghanaan placers (already published by the writer in 1958) is 11 samples with pyrite and 395 bearing gold out of 586 examined. Surely this is of no relevance whatever in explaining how oligomictic quartz-pebble beds can become consistently mineralized with from 2% to 12% pyrite over an area of many tens of thousands of square miles?

It so happens, however, that very much more information is available on the Ghanaan placers than has been published. Soon after the Geological Survey of the Gold Coast was inaugurated in 1913, widespread reconnaissance tours were undertaken to assess the country's mineral resources, in the course of which vast numbers of hand-panned concentrates were collected from river gravels and mine workings. When the Survey's office in London closed down in 1948 upwards of 10,000 of these concentrates, collected between 1916 and 1925, were made available to the writer and were studied under his direction by K. E. Beer and J. Taylor (1953). All the concentrates were assayed radiometrically and those registering more than 0·02% equivalent ThO_2 (comparable to 0·005% eU_3O_8) were given a rigorous mineralogical analysis. Only 107 concentrates out of 10,000 studied had a radioactivity above this limit, this radioactivity being due to monazite, thorite, and zircon. In other words, assuming a minimum concentration ratio of 10 : 1, no more than 1% of these gravels had a radioactivity exceeding a tenth of that of the *least* radioactive banket on the Witwatersrand—and, as with all modern placers, this radioactivity arose essentially from thorium and not uranium. Of these 107 radioactive samples studied mineralogically only one carried detrital pyrite, in minute quantity. Although cubes of pyrite were noted in several of the non-radioactive concentrates not studied in detail, in the light of these results the writer cannot but view with extreme scepticism claims (Nel, 1958) that the content of pyrite in Gold Coast river gravels is in any way comparable to that of the Rand bankets. To equate autochthonous river gravels of polymictic composition and allochthonous sheet gravels of oligomictic make-up, two types of sediment which are genetically quite dissimilar, is to argue from false analogy; and such an ill-founded argument is of value solely as a measure of the lack of thought with which the placer hypothesis is being pursued.

In a recent Russian paper, received whilst this text was in proof, Betekhtin (1959) finds support for placerist views from his experiences in arctic Russia. He records that in heavy mineral concentrates from platinum-prospecting operations around the epidotized gabbro-amphibolite intrusion of Rai-Iz in the Polar Urals, there is an abundance of fresh unoxidized pyrite, sometimes slightly rounded. Further, he notes that pebbles of fresh chalcopyrite can be found in the alluvials of the estuary of the River Severnaya Sos'va, 300 km. away from the Urals. Betekhtin concludes: "These facts convincingly demonstrate that under the conditions of a cold polar climate with a short summer, chemical change of sulphides proceeds very slowly"; and he goes on to suggest that the "detrital" uraninite and pyrite of the banket may have accumulated under such conditions. To these observations it may appropriately be added that in the literature of the Yukon and Alaska there are many records of the survival of detrital sulphides. But the advocates of this solution to the Witwatersrand problem forget that if sulphides survive in arctic alluvium, so does nearly everything else! Ferromagnesian minerals, igneous and metamorphic rock fragments, and all the other metastable components of polymictic alpine or arctic placers have a similarly high survival rate when the temperature of the ground-water approaches freezing point. The problem before the placerists is not just to account for the survival of "detrital" uraninite and pyrite in pebble beds; it is to explain why these minerals are found in payable concentrations only in oligomictic quartz-pebble conglomerates, whilst the commoner polymictic conglomerates in the sequence are barren of workable ore. The only evident explanation is that the mineralization must be related

to the initially greater permeability of the oligomictic strata.

Another basic argument advanced against the placer hypothesis is based on the circumstance that in the banket ores uranium is consistently in excess of thorium, in this contrasting with alluvial deposits of all ages from pre-Cambrian to Recent, in which thorium is invariably in excess of uranium. The evidence given in earlier papers (Davidson, 1951, 1953, 1957) need not be repeated. The soundness of this deduction has lately been impugned by Friedman (1958), Ramdohr (1958*abc*), and Roscoe (1959), all of whom indulge in the quite fallacious reasoning that if a high uranium : thorium ratio is a mark of epigenetic origin, the reverse relationship must necessarily derive from syngenetic deposition. Contemplation of almost any primary thorium deposit exposes this *non sequitur*. All of these authors argue that since at Blind River there is a preponderance of thorium over uranium in the Huronian conglomerates as a whole (though not in the commercial ores) this is evidence of the alluvial nature of *all* the mineralization there. For the Witwatersrand Ramdohr explains that the thorium content arises from a failure of monazite to become concentrated because of the relatively low specific gravity and inferior hardness of this mineral.

This topic has been reviewed elsewhere by the writer (1959), with the conclusion that further work is necessary to demonstrate whether the thorium-rich mineralization is detrital (with a later hydrothermal uranium mineralization locally superimposed on it) or whether the observed distribution is best explained by some form of hydrothermal zoning. Some age determinations on the Blind River ores, not yet reported in full (Derry, 1959), apparently support the former interpretation. The most instructive feature of this mineralization is, however, that in the relatively uranium-rich developments of the bankets the uraninite (with or without brannerite) is almost always accompanied by pyrite, which commonly forms from 2% to 20% of the rock ; whereas in the relatively thorium-rich strata the monazite and thorite associations are largely sulphide-free. Now the specific gravity and hardness of uraninite, pyrite, and monazite are as follows : uraninite, G = 7·5–9·5, H = 5½–6 ; pyrite, G = 4·9–5·2, H = 6–6·5 ; monazite, G = 5·0–5·2, H = 5–5½. Consideration of these figures makes it manifest that if recourse is made to a placer hypothesis it becomes impossible to explain the consistent sympathetic association of the heavy uraninite with the much lighter pyrite, and the antipathetic relationship of pyrite to the equiponderant monazite. No mechanism of hydraulic separation can explain such an association. Consideration of these figures also refutes Ramdohr's claims that the low thorium content of the South African reefs is to be explained in terms of the physical properties of monazite (under a non-oxidizing atmosphere), these claims demanding not only an inversion of the principle of uniformity but also some quite inexplicable behaviour on the part of the force of gravity.

In the search for analogues of the bankets among modern placers we have to bear in mind the repetitive character of the gold-uranium mineralization. In the conglomerates of the Dominion Reef system, in the Government Reef of the Lower Witwatersrand System, in no less than 20 worked reefs of the Upper Witwatersrand System, in the Contact Reef of the Ventersdorp System, and in the Black Reef of the Transvaal System—in all these formations we have the same strange pattern of a payable " alluvial " mineralization bearing gold, uraninite, pyrite, and other sulphides. These five systems, along with their unconformities, occupy the time interval from the Shamwaian orogeny to the Bushveld granitization, a period of 600 m.y., equal to the whole length of geological time from the Lower Cambrian to the present day. We are asked to accept that throughout this vast duration a most unusual detrital assemblage, unparalleled in our knowledge of the sedimentary rocks, has again and again and again been fed into the basins of deposition. There are at least two barriers to the maintenance of this proposition. *First*, it is impossible to envisage (at least within the bounds of the writer's geological understanding) any form of source from which this assemblage could be derived, either consistently or intermittently, for no less than four or five geological periods—any source which could continue to yield this unique detritus whilst being denuded to such an extent that it furnished more than a 7-mile thickness of strata. *Second*, so far as is known from the extensive practical use of heavy-mineral petrology as a means of stratigraphical correlation in oil-fields, this repetitive pattern in the distribution of heavy accessory minerals just does not occur in any investigated major succession of sedimentary rocks.

Before leaving this comparison with modern alluvials it is appropriate to notice some further arguments advanced by Nel (1958), who writes :—

> Particles of uraninite have survived the grinding action of the grinding mills and have been collected on the James tables at some mines in the Witwatersrand and Orange Free State gold fields ; and finer particles of the mineral are being recovered from some slimes dumps (those where there was little or no water percolation) accumulated before the first world war. During the deposition of the bankets conditions could, therefore, have been such that the detrital grains of uraninite were protected against decomposition that usually results when they are exposed to the atmosphere. Favourable climatic environments may have been a factor in the preservation of the detrital particles of uraninite. As far as one can tell it seems that the gold-bearing Witwatersrand conglomerates were deposited and quickly buried by later sediments under water, so that reducing conditions might have been present within them to preserve detrital uraninite grains from solution by oxidizing water.

There is no mention here that, according to Sharpe (discussion in Liebenberg, 1956*a*), only between ½% and 1% of the uraninite in the banket survives a passage through the ball-mills to the gravity tables. We cannot but wonder how, if 99% of the mineral is lost in slimes during a few hours' reduction, the placer uraninite has managed to survive the prolonged natural milling it must have encountered in transport from its source to the quartz-pebble beds. We must ask ourselves what happened to all the fines in that natural milling and why it is that the Witwatersrand shales (which one would expect to contain these fines) are so much less radioactive than the conglomerates. We must weigh without evidence the conclusion that the banket reefs were quickly covered over by later sediments, an assumption that is contrary to all text-book conceptions on the formation of oligomictic conglomerates ; and we must puzzle out without help from South Africa how coarse alluvial deposits can be laid down " where there is little or no water percolation." For such a return of conjecture surely we should have a somewhat greater investment of fact.

Finally, let us look at a new variant of the placer hypothesis lately put forward by Bain (*in* Nel, 1958) who supposes that the uranium in the Witwatersrand strata originally arrived near its present situation as a detrital component, but was later re-organized and redistributed by groundwaters to give new mineral associations distinct from the initial detrital forms. This postulate discards the evidence from mineragraphy and, it seems, rests on nothing more than supposition. Presumably it could be reconciled with the conclusion that the metals are epigenetic to the conglomerate reefs. In this connexion reference may appropriately be made to a previous discussion by the writer (1957), directed towards finding out whether the uranium, gold, and pyrite in the bankets have derived directly as emanations from the granitization, or whether they were concentrated in the more permeable conglomerate horizons by some form of " sweating out " or lateral secretion from the adjoining strata. It was concluded that the normal sandstones of the Witwatersrand geosyncline are significantly richer in gold, uranium, and pyrite than are the arenites of geosynclines that do not contain ore deposits, thus suggesting that the metals are epigenetic to the sediments as a whole. These arguments can now be clarified by more quantitative treatment.

The quantitative data for the Upper Witwatersrand strata have in part been provided by Haughton (*in* Nel, 1958). He records that :—

> In eight bore-holes sunk in the eastern part of the Klerksdorp gold field, which together penetrated 23,066 ft. of Upper Witwatersrand sediments, only 2·8% of the total length of core yielded uranium equivalent values of 0·003% or over. From eight cores in the Orange Free State gold field containing a total of 13,338 ft. of sediments . . . only 1·33% gave values of 0·003% or over. Cores from the Klerksdorp Townlands . . . totalling 10,207 ft. in length gave equivalent U_3O_8 values of 0·003% or over in 5·29% of the total.

A weighted average gives 2·94% (say 3%) of the strata bearing more than 30 parts per million equivalent uranium (in this instance virtually identical to chemical uranium). Part of this 3% comprises the ore zones, and so the *average* content must be *much higher* than 30 p.p.m. Compare this value with the average content of uranium in sandstones, which is no more than 0·45 p.p.m. (Adams and others, 1959). A little calculation shows that even without taking into account any of the ore deposits of the Upper Witwatersrand, and neglecting entirely the uranium content in 97% of the strata there, there is more than enough uranium present in only 3% of the rocks to double the entire uranium content of a whole geosyncline of comparable size formed of normal sandstones. In other words the Witwatersrand basin *as a whole* has been enormously enriched in uranium. Manifestly the uranium must be epigenetic to the geosyncline. The " multiple

migration hypothesis" is thus invalid for these ores.

A similar conclusion can be arrived at from a study of the distribution of the gold. Horwood (1917, pp. 93, 370, 382) notes that the Upper Witwatersrand quartzite contains gold "in traces up to 1 dwt. per (short) ton," a trace being defined as 0·1 dwt./ton or less; and, as already quoted by the writer (1957), Macadam mentions that though "very little" gold was found on assaying 4,000 ft. of quartzite core (at 3–4 assays per foot), amounts were sometimes present ranging from traces to ½ dwt. per ton. Bosazza (1959*b*) claims that such reports of "trace" amounts in the quartzites are of no geochemical significance whatever since a trace, "usually taken at less than 0·2 dwt. per ton," is at the borderline of sensitivity of Rand assay techniques. This borderline grade of 4·8 grains per short ton is however from about three to five times higher than the tenor of alluvial deposits dredged to-day for gold on a large scale—*e.g.*, Pato, Colombia, content of 3½ grains per yard; Bremang, Gold Coast, 2·4 grains per yard; Snowy River, New Zealand, 2 grains per yard. It is a striking measure of the colossal epigenetic enrichment of gold in these Witwatersrand sediments that when the assayers are presented with strata of the overall grade of a workable alluvial field they declare the rock to be barren.

(*To be continued*)

Asbestos in Canada

A brief survey of current activity

Hugh G. Jarman

Asbestos is the basis of one of Canada's oldest industries, yet although the majority of Canadians seem unaware of it asbestos mining has been going on continuously for over 80 years. Ironically the asbestos industry, with but few exceptions, is entirely foreign owned or controlled and over 95% of Canadian asbestos is exported. The United States takes over 75% of all the Canadian output to be used in the manufacture of various products having a value of over $410,000,000 annually. To Canada this industry means receipts of over $90,000,000 for its mined asbestos.

The most expensive mine for asbestos ever opened in Canada was that of Black Lake Mining Co., where a river first had to be diverted from the lake and re-routed away from the company property to rejoin the original river bed further down stream. The deposits at Black Lake were all located under the lake bottom and, after the river had been diverted, huge suction dredges were used to drain the lake and remove millions of cubic yards of silt before mining operations could begin.

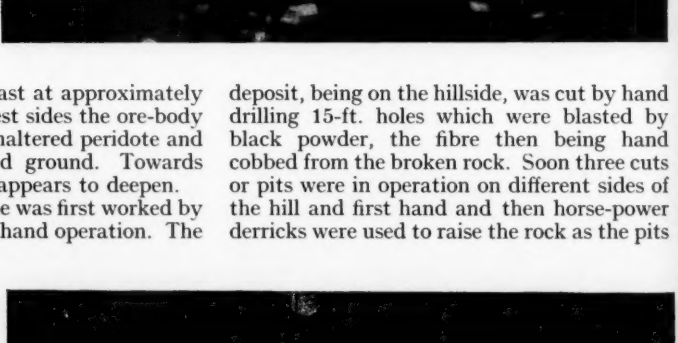
The largest asbestos mine in the world is that owned by Canadian Johns-Manville; its Jeffery mine produces over 500,000 tons of asbestos annually. The company, located in the town of Asbestos, Quebec, is in the centre of Canada's asbestos resources, which are located in a serpentine belt running through the eastern township of Quebec to the Vermont border. In this belt is also included the Thetford mining district, where most of the Asbestos Corporation's mines are located. This company has also a few small mines in Ontario and one in British Columbia.

Mining in the asbestos belt in general follows one pattern, put into operation by the Jeffery mine, the world's largest, some 80 years ago. The fiberized mineral, the ore-body of the Jeffery mine, can be considered as cylindrical in shape, tilted on its long axis and dipping from north-east to south-west. There is no regularity to the fibre content, barren and fiberized masses being found together throughout the mine. About 25% of the ore-body is barren rock. On the north side the ore-body is more regular and in contact with a slate foot-wall, striking north

Noon-Day Blast at Black Lake.

60° and dipping south-east at approximately 45°. On the east and west sides the ore-body fades irregularly unto unaltered peridote and non-commercial fiberized ground. Towards the south the ore-body appears to deepen.

In 1881, when the mine was first worked by Jeffery, it was strictly a hand operation. The deposit, being on the hillside, was cut by hand drilling 15-ft. holes which were blasted by black powder, the fibre then being hand cobbed from the broken rock. Soon three cuts or pits were in operation on different sides of the hill and first hand and then horse-power derricks were used to raise the rock as the pits



Normandie Mine, Asbestos Corporation.

deepened. Eventually the three pits were joined, but became so deep that the use of derricks was no longer possible. An aerial ropeway was then introduced.

At that time aerial-ropeway systems were in general use in all asbestos mines and these became highly efficient in operation. As the workings increased in width, however, the increased length of the ropeway spans began to give considerable trouble owing to cable breakage and a new method of mining had to be planned. The system decided upon, which is still in use today, has been called spiral benching. This consists of mining with power shovels outward and laterally from the sinking cut to the various levels, which are 35 ft. apart vertically and connected by an incline approach.

In the new open pits primary drilling is done from the top of the bench by drills mounted on steel derricks. Holes are collared 15 ft. back from the face and sunk at an angle of 10° to 15° off vertical, sloping towards the face. They are spaced from 3 ft. to 6 ft. apart, according to the rock conditions. All holes are sunk about 4 ft. below grade, thus requiring 40-ft. lengths of steel for the standard 35-ft. bench.

At the Jeffery mine blasting is done with special low-freezing nitroglycerine. Holes are loaded with 30 lb. to 50 lb. of 2 in. by 16 in. dynamite sticks and a maximum of 3,000 lb. of explosives per blast is maintained. All blasting is done by 220-V a.c. current from a blasting cabin equipped with an approved type of blasting switch. The amount of rock broken per blast varies from 300 tons to 25,000 tons. Long asbestos-fibre material is hand picked at the loading faces, but the bulk of the rock is loaded out by electric shovels, which dump directly on to 22½-ton diesel-powered trucks, which transport it directly to the mill slip.

In 1942 the management at Jeffrey made still another change in their mining operations and combined open-pit mining with block-caving, a method so successfully used in the Thetford mines area.

The first development work for this purpose started in 1944 with the sinking of a shaft on February 22, 1950, the underground mine went effectively into operation. Underground operations are laid out and now producing at a capacity of 12,000 tons per day using scram drives with 125-h.p. slusher hoists and 72-in. scrapers which load into 200-cu. ft. tipple cars hauled by a combination 15-ton trolley and battery locomotives controlled by a dispatcher who uses a two-way radio. Track is 36-in. gauge with 85-lb. rails laid on steel ties. The main haulage is a continuous loop and ore is dumped by a two-car rotary tipple into either the waste-ore dump or to feed three 48-in. by 60-in. jaw-crushers, where it goes to a measuring hopper for the 10-ton skip-hoists.

The shaft is steel-timbered, measures 18 ft. by 13 ft. 6 in., inside timbers, has five major compartments—*viz.*, two skip compartments, a cage compartment, a pipe and cage counterweight compartment, and a manway. The steel sets are 6-in. " H " beams and the entire shaft is concrete lined.

The surface plant contains the surge bins, each of 300-ton capacity. The bottom of the surge bins have vibrating feeders emptying into a 36-in. wide conveyor-belt with a capacity of 750 tons per hour, up an incline of over 15° and 275 ft. long. The conveyor-belt has its own housing and feeds into a two-way hopper which dumps into either the waste or the ore bin. The ore bin holds 1,000 tons and the waste bin holds a live capacity of 650 tons, the latter feeding directly into standard railway cars for transport by train to the dump ; the ore bin feeds directly on to the mill-conveyor tunnel.

The change house—of the hang-up and locker type, with a capacity for 500 men—

Mobile Drill at Normandie.

has showers, wash basins, and sun lamps and also contains a 30-capacity locker room for officials, first aid, etc.

The hoisting equipment consists of two Ward-Leonard amplidyne-controlled hoists. The man hoist is a 200-h.p. unit with a single 10 ft. diameter drum grooved for $1\frac{3}{4}$-in. wire rope and capable of hoisting the 50-man, 12,000-lb. cage with a 13,000-lb. load and a 18,500-lb. counterweight at a normal speed of 500 f.p.m. At a reduced speed and with a 25,000-lb. counter-weight it can hoist a 26,000-lb. locomotive. The ore hoist is a 1,000-h.p. unit with two 10 ft. diameter drums grooved for a $1\frac{3}{4}$-in. wire rope. It will handle two 12,000-lb. skips in balance, one carrying 21,200 lb. of material; at a speed of 1,200 f.p.m. a trip takes 75 sec., allowing 10 sec. for loading.

Underground a rotary tipple is situated at the shaft end of the 750-ft. level, with its control panels in a concrete-lined station. When the tipple operates one truck dumps into a 130-ton waste bin and the other into a 260-ton ore bin. Both bins are steel lined and anchored into concrete. The crusher room is on the 816-ft. level; it is constructed entirely of reinforced concrete and comprises two 48-in. by 60-in. jaw-crushers with 200-h.p. drives. These are fed by grizzley vibrating feeders from the waste and ore bins, No. 1 crusher feed coming from the waste bin and No. 2 crusher feed from the ore bin.

Two 10-ton capacity measuring pockets are placed in a concrete station at the 940-ft. level. Discharge from the pockets into the skips is by means of air-operated, quick-action hinged gates, with manganese-lined chutes at 50°. A 35-ton spill pocket is built under the skip loading position at the 990-ft. level; this is steel lined for 24 ft. and dumps into a small concrete-lined loader station in which a transfer carriage is installed, to be pushed under the spill pocket discharge gates.

Electrical power is taken underground at 2,200-V a.c. by armoured cables to the 750-ft. level and thence to a main bus-bar station; from this it is distributed to various points underground.

Compressed air is taken underground from the compressor *via* an 8-in. diameter main down the shaft and distributed throughout the mine by 6-in., 4-in., and 2-in. pipes. Service water goes into the mine by means of a 4-in. main down the shaft and is distributed throughout the mine by way of 4-in., 2-in., and 1-in. pipes.

Waste water is drained from the mine by concrete-lined ditches running along the drives and cross-cuts into two sumps on the 750-ft. level; the water is pumped out of the sumps by two pumps having a head of 850-ft., water at the 990-ft. level being drained into sumps and pumped from the 990-ft. level sumps up to the 750-ft. level by means of a float-controlled motor pump.

Ventilation is provided through a 60-in. "Axivane" fan having a capacity of 85,000 c.f.m. at 3·65 in. W.G. It draws the foul air out of each slusher into the shaft and to the surface. Fresh air is drawn down No. 1 shaft, up the haulage ways, and into the slusher drives *via* the loading openings.

There is a concreting plant underground, complete with a "pump-crete" machine for work on the tunnels as the mine advances forward.

Underground blocks are developed 200 ft. by 200 ft. square. When excavations around the block are completed and suitable escape routes have been completed the fringe is drilled for blasting, the explosives used for fringe blasting consisting usually of about equal amounts of $1\frac{1}{8}$ in. by 8 in. "Forcite" and 70% "Driftite." In raising by diamond drilling $1\frac{1}{8}$ in. by 8 in. 55% "Stopeite" is used, electric detonation being used throughout. Fringe drives are only used for initial caving, afterwards free caving is used.

As previously mentioned actual underground production was started at this mine in February, 1950, when the first undercut was blasted. To-day this mine is producing its full capacity of 12,000 tons daily, made possible by accelerated development and consequent opening to production of other areas.

Canadian asbestos is to-day, after 80 years of continuous operation, still one of Canada's major mining industries. According to informed opinions asbestos supplies still unmined should continue available for the next 100 years.

Ore-Dressing Notes

(3) *Gravity Concentration.*

Jigging (1)

It is possible to approach the consideration of particle dynamics as these are utilized in jigging from several standpoints and, as a result, to over-simplify a somewhat confused balance of forces. The dynamic forces

at work on each particle in the jig box include those which provide elutriation, initial acceleration of fall from rest, horizontal stratification in streaming, progressive changes in load density between feed and discharge rate of lateral displacement of jigged strata, and kinetic modifications in streaming due to shape, porosity, and back pressure on the jigged load.

The interplay between the large number of factors thus summarized is considerable. Any equation designed to give a clear picture of jig action must therefore be empirical and must be specific to a given set of conditions in the ore being treated. These will include : (1) Percentage of heavy mineral to be removed by jigging ; (2) density ratio between heavy and light mineral ; (3) breaking mode of ore—*i.e.*, characteristic particle shape and percentages of clean concentrate, middling, and gangue in feed ; (4) tolerable maximum and minimum mesh sized in feed and sizing analysis ; (5) overall density of jig load (solids *plus* water-filled voids) at feed end ; (6) rate of change of (5) between feed and discharge if jigging through the screen ; (7) rate of change of density of horizontal layers between feed and discharge, and (8) specific surface of jig-load.

The value of careful testing of the ore which is proposed for jig treatment thus becomes apparent. At the same time it is desirable to consider one by one the forces at work in jigging, in order that technical control may best be exercised. Although the permutations of the basic factors entering ore-processing by any given method are numerous, it is always possible to keep a few dominant forces in balance or in a position of major influence. Jigging control is no exception and basic awareness of its directive forces is therefore desirable. The incidence of factors already set out on the operation can now be considered in isolation.

Elutriation of the single particle is a conflict between its mass and the upward urge of hydraulic water exerted upon its surface and its cross-section. In jigging the particle is so large that a very rapid hydraulic current would be needed to carry it upward. Since this would be impracticable a pulsed upward current of controlled strength is used instead. Elutriation for the single particle now becomes complex. The current accelerates from rest at a rate which, if plotted, would show a sine curve. The particle's inertia is overcome at some point along the upward portion of this sine curve and it commences to rise. If it is light and small this action begins while the hydraulic pace is quickening ; if large and heavy, as the water decelerates toward rest near the top of the pulsion stroke. Thus while the water rises faster than the particle the latter is acquiring kinetic energy. When the situation is reversed the particle loses kinetic energy. This effect is complicated by the fact that the water is now either decelerating toward the end of its pulsion stroke or has actually begun to gather downward momentum on its suction stroke. The picture usually given, of a particle accelerating from rest on commencement of the pulsion stroke, is therefore oversimplified. Actually its movement is in phase with that of the hydraulic force, but the point of its reversal and the kind of fluid force acting at the moment of reversal varies from particle to particle. One may start to fall during the dying out of pulsion, while another may only dissipate its upward-pushing kinetic energy during the suction stroke. The acceleration from rest in the two cases would be different and so would the take-up of hydraulic energy by the moving particles concerned.

When consideration moves from the effect of reciprocally-pulsed elutriation on a single particle to the mass effect on the mineral contents of the jig box an extremely complex situation is revealed. Graduated teetering is at work, with the top of the load well expanded and the bottom rather close-packed. It might be suggested tentatively that the course pursued by a light particle (L) entrained at the feed end of the box would influence its relatively high rise because, first, its smaller mass (compared with a heavy particle H of the same size and shape) would respond earlier to hydraulic pulsion ; secondly, because the moment when it lost its upward momentum L would have travelled further than H because it began earlier and it travelled faster, and, thirdly, because L would have acquired more energy during its lengthier rising period.

These considerations should operate in a crowded and teetering bed despite the severe restriction on movement of the constituent particles. In the jig box the applied hydraulic force exerts a general pressure equal to the back pressure of the teetering load *plus* the energy needed to replace frictional loss during flow. Since the hydraulic water is continuously changing its course in order to utilize the channels offering the least resistance, there is momentary excess turbulence

at points where this has resulted in increased flow. The generalized picture of the pulsion stroke therefore includes local disturbance and stirring in the general teeter. Pulsion only accounts for part of half a stroke, however. It is usual to assume that when no water is added to that being pumped up and down pulsion and suction are equal. This is not strictly true, apart from any loss due to leakage around the pumping mechanism, since the pulsion stroke consumes power by lifting the bed against its gravitational force, whereas the suction stroke is reinforced by the downward movement of the collapsing teeter. When extra water is added in the jigging cycle it can be assumed to have a generalized loosening effect with mechanisms of the Harz type and to be more specific in its influence on teeter-collapse with the Denver, which admits its extra water only during a set fraction of the jigging cycle. Jigs are operated commercially at speeds varying from 120 cycles/min. to 330 cycles/min. and the condition thus far referred to as an expanding and collapsing teeter can also be considered as one of plastic flow. With impulses arriving from two to five or more times a second, and the whole bed being pushed toward the discharge end by the incoming feed, the individual particles tend to dance sideways as well as to work their way to an appropriate stratifying layer.

The effects of other factors now appear. The stirring effect of the strokes helps the particles to " swim " in a density nearer that of water than of a dense media. The same stirring action reduces the friction and opens the texture of the mass. As new feed enters an equivalent quantity is discharged from the jig box. A new factor now enters, since at any vertical cross-section the bed density (ore *plus* water) is falling steadily from feed to discharge. Since the hydraulic lift is more or less equal over the whole bottom area this means that the bed expands slightly in thickness to compensate for its reduced mass. It is common practice to arrange a series of jig compartments so that the tailings climb slightly as they move to the next box. The reason commonly given is that this prevents violent overflow and its consequent disturbance of stratifying action. Here is a reinforcing reason for such an arrangement.

E. J. P.

(4) *Design.*

Value of Planning

In a recent article R. J. Linney [1] details a number of important operating economies which resulted through good design, good co-operation with the manufacturers and installing engineers, and in general operational research. The Reserve Mining Co. produces 5,000,000 tons of iron ore annually from a plant designed to produce 3,750,000 tons. To handle the extra ore all that was needed was a fifth fine crushing line and a few minor changes. This was achieved within a year of the original start and is considered to emphasize the value of the basic engineering that went into the job.

One point stressed repeatedly is that ample space was allowed round the machines and for any necessary extensions. Although this adds to the initial cost it is considered to have justified itself handsomely during the years the plant has now operated. Gravity flow commences at a point 270 ft. above Lake Superior, where the mined ore is dumped. Only the closed circuit between cone classifiers and ball-mills requires pumping and no machine is set directly above another, so that the whole activity is easily viewed. Milling began in August, 1955, and stopped on the same day for modifications to the transport system of the first parallel line where spillage had occurred. This re-adjustment continued for a week and the corrective measures were then incorporated on the other eleven sections of the mill. As a result these started almost without a hitch. In the coarse crushing plant undue wear occurred when piano-sized pieces of rock came into the three-piece mantles of the heavy gyratories. Redesign of the concaves in a two-piece mantle and improved blasting to eliminate such huge pieces of rock prolonged the life of the liners from their original 600,000 tons to more than three times the duty. The first reline in 1955 took over 120 hours and as a result special tools were made and the work was brought down to below 38 hours. Routine relining is now a highly organized job.

One difficulty which had not been foreseen was the freezing of the ore in the trucks in winter temperatures, which are 40° F. below zero. After one serious experience with this a permanent feeder was set up which adds one pound of calcium chloride per ton of

[1] *Min. Engg.*, Sept., 1959.

ore and has eliminated freeze-up troubles at even this low temperature. Another difficulty arose with undue wear on the railroad car wheels which soon came into the workshop at the rate of up to 350 a month for overhaul. When overloading was eliminated and the cars were turned end for end periodically so that they ran loaded in one direction and empty in the other for regular periods of time there was improvement. This, together with special rim treating of the wheels, has reduced the wear rate. In the fine crushers the liners last about 1·8 days and originally required 12 hours for change. A spare bowl, shaft, and head centre were obtained so that the manganese-steel liners could be set in zinc before the change over. This reduced the time considerably and, together with detailed study of the operation, the original 12 hours of change now requires just over half an hour. In the magnetic separating section there were originally two cobbing machines for each of the twelve mill sections. When the tonnage was loaded up there was trouble with this, but a re-adjustment which required the introduction of a third drum put the matter straight. This was only possible because the original design had allowed space for such an installation. Liner wear with this highly-abrasive material (taconite) is heavy. The primary crusher alone used up over 1,000 tons of liner in its first year of operation and the total for crushing and grinding was nearly 16,000 tons costing $4,000,000. Careful study and experiment with a wide variety of alloys, liner shapes, lifter bars, etc. made it possible to effect considerable economies in this section. These and a number of other operating economies are detailed in this very practical article on large-scale crushing and grinding with a moderately simple concentrating treatment and pelletizing to follow.

Book Reviews

The Future of Non-Ferrous Mining in Great Britain and Ireland : A Symposium. Cloth, octavo, 614 pages, illustrated. Price 60s. London : Institution of Mining and Metallurgy.

This volume, well produced and well indexed, contains the proceedings of the Symposium arranged by the Institution of Mining and Metallurgy in collaboration with the United Kingdom Metal Mining Association and held in September, 1958. The papers and discussions now available comprise an up-to-date appraisal of the present position and possibilities of non-ferrous mining in all the districts in the United Kingdom and Ireland where mining has been carried on, chiefly, alas, in the past. Such matters as taxation, choice of prospecting methods, etc., are also covered, so that an immense amount of information, past and recent, on the geology, output, and other matters of interest regarding British mines is assembled in one compact volume. An interested person will in future be saved the time-wasting research which would otherwise be required in obtaining these facts from dispersed sources. To the reviewer this by itself is sufficient justification for the holding of this Symposium.

The main purpose of the Symposium was to prepare a foundation of fact and opinion on which to build a new approach to the Government for assistance, since earlier attempts have not been successful in arousing the interest of the authorities in a revival of non-ferrous mining. The sponsors felt a change of attitude unlikely unless Government could be confronted with new evidence " that the industry does, in fact, possess the potential to develop." To this end it is obvious new ore reserves are required before any such revival can be contemplated. Opinion was unanimous these are not to be found (with some exceptions) by re-opening old mines and that such work is usually a waste of money and time. All were agreed, however, that new, concealed, virgin deposits are to be expected in at least some fields, the most favourable locations being considered to be Derbyshire, the Northern Pennines, North Wales, and parts of Cornwall. It should be noted that non-ferrous mining is by no means extinct, as some 20 mines, mostly in the Pennines, are still at work. The tin of Cornwall is well known, but it must not be forgotten that other properties yield some 400,000 tons/year of fluorspar and barium ores, together with some lead and zinc as by-products. This production is expected to continue for a long time.

As the main hope of new reserves is in concealed deposits the search for them is likely to be unusually speculative and costly and the money required is unlikely to be forthcoming from private sources unless the Government " creates the necessary encouraging climate." The form of Government assistance desired by many speakers was tax relief, which has, of course, been suggested for a long time past and some

minor concessions were made, it will be remembered, in 1945 and 1952. The Royal Commission on Taxation and Profits recommended further reform in 1955 but this has so far not been proceeded with. However, an additional, or alternative, form of aid, strongly recommended, was that Government should support technical agencies (or a Committee) whose task would be to collect additional basic information so that exploration in the field, which could profit also from a more intensive interest on the part of the Geological Survey, can be better planned. It seems probable that this latter approach is likely to be the more successful, seeing that Government was firmly against tax concessions as late as December, 1956. Opinion was divided on the desirability of the purchase by the State of mineral rights, but on the whole was not convinced it is necessary. In any case, with so many demands on the Public purse which are politically more glamorous, such as new roads, schools, houses, etc., it seems to the reviewer unlikely the Treasury will be in a hurry to find money for such a purpose.

It is evident that the Government is not averse to assisting industries in trouble—such as, for example, cotton textiles. More recently it has been agreed that public money ought to be used to encourage new industry in areas of persistent unemployment. It may be, therefore, that the attitude of Government towards non-ferrous mining might change suddenly and unexpectedly. Meanwhile, it seems to the reviewer, the most fruitful course would be to try and get Government to support the suggested technical agencies or a Committee which would carry on with the spade work of study and exploration.

JAMES RUSSELL.

Asbestos : Its Origin, Production, and Utilization. By W. E. SINCLAIR. Second edition, revised and enlarged. Cloth, octavo, 512 pages, illustrated. Price 60s. London : Mining Publications, Ltd.

Since the production of the first edition in 1955 this book has proved extremely useful as a work of reference, for there is no other work devoted entirely to this material. The present edition is more than a third larger than its predecessor, almost entirely by the addition of the review of the Canadian asbestos industry and an American survey. This results in a great improvement when one takes into account the leading position of Canada as a producer of the mineral.

In the body of the book there is not a great deal of change. The reviewer still considers the geology the worst section, but again totally absolves the author in this respect as he makes quite clear the lack of knowledge on the origin of the more important varieties of asbestos. There is no doubt that the sections on classification and marketing are again most valuable and that the volume will remain a reference work for a long time. Had this book not appeared the earlier edition would, even now, have remained the best thing of its kind.

Finally, the reviewer would like to repeat in almost the same words his final statement to the review of the first edition ; the work is not a mere compilation—the author shows himself as having devoted many years to field study of asbestos and considerable thought to codifying our knowledge of it.

R. A. MACKAY.

A Century of Metal Broking, 1859–1959. By GODFREY HARRISON. Cloth, octavo, 103 pages, illustrated. Price 21s. London : Vivian, Younger, and Bond, Ltd. (obtainable only from the publishers).

The volume noticed here records 100 years of existence of the firm of Vivian, Younger, and Bond, Ltd., which started in business on January 1, 1860, at 27, Bucklersbury, E.C., as Vivian and Younger. Covering a period closely related to the expansion of British industry and the development of mining within the Commonwealth, it is also the story of the supply of metals, principally of tin. The formation of what is now known as the London Metal Exchange and the ultimate emergence of the British Metal Corporation is also covered. The organization, together with Henry Gardner and Co., Ltd., comprise the Amalgamated Metal Corporation, with all its many interests in the world of non-ferrous metals. Much of the history is concerned with one man, Sir Cecil Budd, who during his lifetime, played an important part in the development of the non-ferrous metals trade.

There also emerges a story of development in other fields, in Nigeria and Malaya, for example—as well as an account of the growth of the company's associations with Cornwall and Australia. The whole makes a success story that in its telling covers a century of honest endeavour.

Process Integration and Instrumentation : Electricity and Productivity Series No. 8. Cloth, octavo, 204 pages, illustrated. Price 8s. 6d. (9s. post free). London : Electrical Development Association.

This well-prepared volume contains an account of the various steps which lead from detection and measurement to indication, recording, and, eventually, automatic process control. Elements of chemical, physical, electrical, mechanical, electronic, and nuclear engineering are involved, all of which have their peculiar and rapidly extending vocabularies. The book outlines the means by which the variables occurring in manufacturing can be sensed, measured, and controlled, with the ultimate object of achieving a more completely and perfectly integrated process.

☛ Copies of the books, etc., mentioned under the heading " Book Reviews " can be obtained through the Technical Bookshop of *The Mining Magazine*, 482, Salisbury House, London, E.C.2.

Engineering Log

Recent research in related fields has brought about a revival of interest in the plasma generator as a power source. Generators of this type produce electric power by direct means from a gaseous jet of electrons and positive ions. The inherent thermal efficiency of such a machine is between 40% and 50%. In America the General Electric Company's aerosciences laboratory has now built an experimental model plasma generator, which put out 1 kWh of electric power during a test lasting 5 sec. The device operates on the induction principle and uses a powerful electromagnet and a plasma jet blasting through a quartz nozzle. The nozzle is set between the magnetic poles and the plasma ions cut magnetic lines of force spiralling towards the nozzle wall as they rush through the nozzle. These lines of force are drained off as current by means of a pair of graphite electrodes. The model falls short of the theoretical ideal both in size and performance, efficiency proving very low with a 600-lb. magnet and plasma heated to 8,000° F. The company believes, however, that in two years a lighter smaller model can be built, able to operate in the 5,000° atmosphere of a rocket exhaust and capable of producing enough power in a two or three second burst to transmit a strong signal from a space vehicle. Although various types of plasma generator have already been patented in various countries a practical model has been brought in sight only by recent efforts to control thermonuclear reactions. These efforts have yielded fuller understanding of the behaviour of plasmas.[1]

* * *

From information given by the Czechoslovak News Agency (ČTK) it appears that fundamental seismic and magnetic maps of Czechoslovakia have recently been completed at the Geophysical Institute of the Academy of Sciences in Prague. These maps will be a contribution to earth tremor research in Europe and should also serve in considering the structure of large buildings in earth-tremor zones. The magnetic maps will form part of the basis for detailed land and air surveying destined to locate mineral deposits. It is also reported in connexion with the completion of geological maps that prospecting is being intensified with the most modern equipment, much of it of Russian design. A press report from Prague indicates that new deposits, wolfram, have been found in the Krkonoše Mountains region, as well as tin-wolfram and fluorite-barite in the Krušné Mountains of West Bohemia.

* * *

Government science, and probably all British science, is at present too parochially minded, too departmentalized, and it seems evident that more generalized philosophy and approach is needed. The channel Lord Hailsham, the first Minister of Science, proposes to use is the existing Advisory Council on Scientific Policy, which will be called on for more generalized advice on scientific matters. There will also be other channels of aid, such as the Overseas Research Council, which is expected to act as a clearing house for research efforts in the Dominions and overseas territories. The new Minister has no authority over the universities or over the University Arts Committee, nor apparently has he any designs on their present autonomy. He hopes to forge friendly links with both and he recognizes, according to recent policy statements, the essential value of science and scientific matters as taught in the universities. In the schools the teaching of science and mathematics will not be overlooked and the contact here will be through the Ministry of Education. Obviously

[1] *Scientific American*, Dec., 1959.

in a single term of office only a foundation can be laid for a genuinely scientific approach to present-day problems. Lord Hailsham's statements should be of considerable interest and encouragement both to science and to industry, which to an increasing extent relies on the application of scientific method.

* * *

The reconnaissance survey for uranium, carried out by the Atomic Energy Division of the U.K. Geological Survey in the last two years, is now virtually complete, it has been announced. In the course of the search, which has included an aerial survey of Cornwall, Devon, and much of Somerset, as well as surface mapping, excavating, and drilling at promising localities, 70 new occurrences have been found. No economic deposit has been discovered, however, and it is concluded that if any are present they are covered to such a depth with soil or overburden that they are unlikely to be detected by existing instruments. The South-West of England uranium province has served for many years as an ideal testing ground for British geological electronic equipment, while the study in Cornwall and Devon, started in 1945, has played an important part in the discovery of uranium in the Commonwealth, as well as in the development of aeroradiometric surveying techniques. A scientific assessment of the aerial survey technique, read at the 1958 Geneva conference on the Peaceful Uses of Atomic Energy, was widely acclaimed.

* * *

Volume mixing of rubber compounds is almost invariably carried out in internal mixers and although during the last 30 years these machines have been improved and become faster, more powerful, and available with more automatic control than before, no radical changes in design have been effected, mixing being still done on a batch basis. At the November International Rubber Conference in Washington, D.C., a new mixer, the Rotomill, was unveiled. This machine is a product of the B.F. Goodrich Research Center and is believed by its sponsors to be the first practical device for mixing a wide range of rubber compositions by a continuous process. Two machines have been built so far, the larger of these being a laboratory model with 5½-in. rotor, able to mix 100 lb. of rubber stock in an hour. A 10-in. machine is now planned and preliminary calculations have been made for a 20-in. unit. Continuous mixing is likely, it is thought, to give better control, uniformity, and economy. Power consumption is said to be equal to or a little higher than that of a conventional internal mixer, but high peaks are eliminated. Another advantage is that since mixing temperatures are fairly low all curing ingredients may be added in one operation without risk of scorching the stock. The Rotomill is also capable of use as a warm-up mill to feed other units of equipment and has been used to blend polymers and to plasticize polyvinyl chloride.[1]

* * *

The fast reactor at Dounreay "went critical" last November, some 20 months behind the original schedule. The delay was due to a mixture of technical, economic, and political causes and the full significance of the new British achievement may not be so widely appreciated and welcomed as it should be. Unlike the Calder Hall type of reactor, with its massive construction and moderating graphite blocks, the dust-bin sized core of the Dounreay is as near in design to an atomic bomb as safety allows. Fission, unchecked by moderators, produces its chain reaction at full speed, the resulting heat being removed from the core by means of a sodium-potassium alloy. Although fast reactors are commonly thought of as complementary to the slow gas-cooled type because they utilize the latter's by-product plutonium these fast reactors can be self-contained, since they "breed" more plutonium than they consume. The core at Dounreay is surrounded by a blanket of uranium in which plutonium is produced by escaping neutrons. In place of ordinary uranium a blanket of thorium could be used, when U 233 would be bred. The fast reactor must use pure fissile fuel and experience at Dounreay must accumulate before its place as a power generator can be properly seen. Should disarmament succeed in ending the military demand for plutonium it might be found that a combination of gas-cooled slow reactors with the fast ones requiring specially rich fuel is the answer to the coming pattern of power production from nuclear fission, rather than a completely do-it-yourself fast breeder.

[1] *Chem. Eng. News*, Nov. 23, 1959.

Results of a re-study of the red iron ores of north-east Alabama, north-west Georgia, and east Tennessee are presented in a report entitled a " Review of Southeastern Iron Ores Exclusive of the Birmingham District, with Emphasis on the Silurian Hard Red Ores ", resulting from a compilation of existing data by the U.S. Geological Survey and the evaluation of economic factors by the Bureau of Mines. Potential ore in beds of Clinton (Silurian) age outside the area immediately tributary to Birmingham, Alabama, probably totals at least 5,000,000,000 tons, but most of this is only 2½ ft. to 3 ft. thick, contrasted to an average thickness of about 8 ft. in Birmingham. In addition, unlike the commercial Birmingham ore, the average grade is too low to permit economical furnacing without beneficiation.

The report has two maps, scale about 4 miles to the inch, covering the area from the vicinity of Gadsden, Alabama, to the Tennessee-Kentucky border, which show the outcrops, thickness of ore beds, chemical analyses, and areas underlain by ore. Two sheets of cross-sections show the pertinent structural features and depth of the ore horizon.

* * *

On November 6 Britain's first privately-owned research reactor was opened by the Duke of Edinburgh at the Associated Electrical Industries, Ltd., Research Laboratory, Aldermaston Court, Berkshire. The new reactor, known as " Merlin ", was built by the A.E.I.-John Thompson Nuclear Energy Co., Ltd., and uses enriched uranium fuel elements in an aluminium tank with light water for moderator. Criticality having been reached in July, power will now be gradually increased until the maximum of 5 MW is reached. Merlin's three main uses will be as a training unit, as a prototype, and as a source of neutrons for the research, testing, and development programmes of A.E.I. Reactors based on Merlin experience are already being constructed for the United Kingdom Atomic Energy Authority and the West German Government. Merlin will be used to train both undergraduate and graduate students and its projected research programme includes the following :—Study of radiation effects on materials, study of Cerenkov radiation as a method of power measurement and means of detecting escape of fission products from faulty elements, search for improved data on neutron and photon absorption for shielding materials, finding critical temperature range for accelerated creep of reactor metals, study of irradiation rate effect on fuel element life, study of reactor safety, production of short-lived radioactive isotopes, activation analysis to detect minute impurities by irradiation, and study of measurement methods to find neutron energy distribution in the vicinity of the reactor.

* * *

Professor N. N. Sytinskaya of the Main Astronomical Observatory of the U.S.S.R. Academy of Sciences is convinced that the surface of the moon is composed of a porous material, resembling slag from volcanoes, but formed on the moon's surface when meteors smash against the rocks of the lunar crust. This conclusion, based on photometric, colorimetric, and polarimetric studies of the moon, was reached before Russia's two recent moon shots. Professor Sytinskaya believes the lunar atmosphere, if it exists, to be so thin that even extremely small meteorites reach the moon's surface at velocities high enough to cause explosions. Micrometeorites strike the surface at the rate of 2½ per sq. in. per min. and, according to her theory, this fact alone is enough to form a continuous film of modified material in a short time. The slag material formed in this way is dark in colour because of the breakdown of silicates and formation of black iron oxides. The lunar seas are darker than the continents because the original rocks of these regions were higher in iron content. Professor Sytinskaya suggests that in the region of the seas slag is formed over ultrabasic rocks, whereas in the continental regions it is formed over basic and perhaps partly over intermediate rocks. She reports her work in the Soviet journal *Astronomicheskaiia Zhurnal*, of which an English translation entitled *Soviet Astronomy—AJ* is published by the American Institute of Physics.

* * *

A super-sensitive gravity meter has been designed for use to detect holes under roads before the surface caves in. The instrument has been developed by Texas Instruments, Inc., Houston, Texas, under specifications of the Franklin Institute, in answer to the City of Philadelphia's needs. Gas and electricity companies there required some method of detecting a dangerous cavity before the subsidence occurred, with possible unforeseen

damage to public utilities and the hazards attendant on such damage. The detector is based on the theory that a cavity, since it represents the removal of an attracting mass, will reflect a small decrease in gravity. It has a small weight at the end of a delicate spring and over a cavity the spring contracts. This contraction is observed by means of a microscope. A cavity of as little as 23 cu. ft. can be detected by this sensitive instrument; the meter reflects as small a deviation from normal gravity as 4 parts per billion. It is a long-period instrument, so that the weight moves on its spring very slowly, and will not be affected by use in close juxtaposition to a jack-hammer. It is affected by slow earth vibrations, such as those of the Alaskan earthquake, however. Under normal conditions buildings, changes in elevation, and the sun and moon all produce measurable changes. The process of moving 400 ft. along a street running north and south affects the reading by 26 divisions of the scale because of the alteration in latitude. These changes are all gradual. Any sudden change indicates a cavity beneath the instrument.[1]

* * *

A 100-ft. experimental plastic balloon, aluminium coated, and inflated in space with four lb. of water vapour, will provide a new "star" in the twilight sky next spring. The United States National Aeronautics and Space Administration's "Project Echo", in which three such balloons will be used, is designed to test processes of using a satellite as a reflector for radio and television waves on a world-wide basis. This first experimental balloon is due to be launched at an angle of 50° to the equator from the Cape Canaveral launching site. It is expected to be seen from all parts of the United States except Alaska. The duration of the balloon's lifespan in its scheduled 1,000-mile-high orbit is another question. It is uncertain whether it may last, as do some other satellites, for several years, or whether its bulk will render it so vulnerable to atmospheric drag and to the impact of meteorites that, even at 1,000 miles high, it may complete only a few earth orbits of 120 minutes each. N.A.S.A hopes that by announcing the experiment in advance—not usual policy—it will enable communications experts to use the balloon for their experiments. N.A.S.A. itself plans to use the balloon to bounce radio signals between the two radio stations of the Jet Propulsion Laboratory's Goldstone tracking station in California and Bell Telephone's Laboratory station at Holundel in New Jersey. The balloon is similar to one used in a test shot recently from Wallops Island, Virginia. The new balloon is expected to travel across countries lying between 50° north and 50° south latitude. This will take it up to the Canadian border and down to the southern tip of Argentina in the Western hemisphere; while in the Eastern hemisphere it will traverse Le Havre, Prague, Kharkov, and reach south to Tasmania.[1]

[1] *Science News Letter*, Jan. 2, 1960.

News Letters

BRITISH COLUMBIA

January 11.

Mineral Production.—The value of mineral production in British Columbia during 1959 has been estimated at $154,400,000 by the Hon. W. K. Kiernan, the Minister of Mines. The figure represents about a 500 advance over the recorded value of $146,875,081 for 1958. The 1959 estimates, with 1958 final figures in brackets, are: Gold, $6,200,000 ($6,762,000); silver, $7,300,000 ($6,086,000); copper, $3,800,000 ($2,964,529); lead, $34,800,000 ($34,627,075); zinc, $43,800,000 ($43,234,839); iron *plus* nickel, $6,700,000 ($5,189,949); by-product metals, including antimony, bismuth, cadmium, indium, and tin, $4,400,000 ($3,501,637); industrial minerals, including asbestos, sulphur, gypsum, and others, $14,000,000 ($11,763,473); structural materials, including clay products, cement, lime and limestone, rock, building stone, sand, and gravel, $22,200,000 ($19,999,576); coal, $5,200,000 ($5,937,860); petroleum and natural gas, $6,000,000 ($4,923,615).

Cominco.—The Consolidated Mining and Smelting Co. of Canada, Ltd., commenced construction of a $2,600,000 alkali-chlorine plant at the Trail smelter last month. The company's decision to enter this phase of heavy chemical manufacture came with the signing of a sales agreement with Celgar, Ltd., which has a $50,000,000 kraft-pulp mill and new sawmill under construction near Castlegar, 20 miles north of Trail. Cominco will supply the liquid chlorine and caustic soda required for pulp manufacture and the new plant will also produce potassium hydroxide for Cominco's own processes at Trail. Mr. R. D. Perry, vice-president and general manager, said Cominco has marketed some industrial chemicals in the past, but in recent years has made new studies in this field. He noted that chlorine, caustic soda, and potassium hydroxide were logical chemicals for expansion for several reasons.

[1] *Science News Letter*, Jan. 2, 1960.

The new plant is to be located at the chemical fertilizer site, where an established electrolytic process will be used requiring about 25,000,000 kWhrs of energy per year from Cominco's power resources. The sodium chloride needed will be obtained from the Canadian Prairie. Completion of plant construction is expected by the end of 1960.

Conwest Exploration.—Two subsidiaries of the Conwest Exploration Co., Ltd., have reported very successful operation in the fiscal year ended September 30, 1959 :—

The Cassiar Asbestos Corporation, Ltd., earned an operating profit of $4,330,552 and a final net profit of $3,043,579 after provision for depletion, depreciation, and taxes. Working capital was increased by more than $1,000,000 to $4,931,576. The mine at Cassiar was operated for seven months, delivering 312,759 tons of ore to the mill site after removal of 1,130,877 tons of waste. Ore from underground exploration is being milled and tested on a production scale. Results to date indicate both grade and quality are the same as the ore being mined on surface. Mr. J. D. Christian, the general manager, states : " During the past two years the sales commitments have required that the mill operate at full capacity on a year-round basis. This and the normal growth pattern have made necessary the installation of equipment which will increase the daily capacity from approximately 1,000 tons to 1,500 tons a day. The estimated cost of the expansion, including necessary construction, is $150,000 and the work is scheduled for completion early in 1960."

United Keno Hill Mines, Ltd., earned an operating profit of $2,266,520 and increased working capital by almost $1,000,000. The operating statement for the year shows sales of concentrates at $9,058,292 and other income of $48,314, the net profit being $1,324,836. Production consisted of 16,074 tons of lead concentrate and 13,767 tons of zinc concentrate containing 6,816,821 oz. of silver, 22,865,276 lb. of lead, 17,717,019 lb. of zinc, and 220,281 lb. of cadmium. The ore reserves at the year end were estimated at 549,565 tons assaying 38·21 oz. of silver per ton, with 6·60% lead and 4·89% zinc, not inclusive of the reserves of the Onek mine, which are estimated at 123,491 tons assaying 10·27 oz. of silver per ton with 4·4% lead and 13·0% zinc.

Skeena.—During a period in the late autumn Tom McQuillan and associates mined, cobbed, and shipped 62 tons of high-grade precious and base-metal ore from an abandoned glory hole on the property of Silbak Premier Mines, Ltd., near Stewart. Returns from the Trail smelter covering 51 tons of the shipment show average content of 11·85 oz. of gold and 299 oz. of sllver per ton, with 15% combined lead and zinc. The " leasers " plan to return and again work the property as soon as weather conditions permit.

Silver Standard Mines has entered into a preliminary agreement with the Sumitomo Group, Japanese iron and steel manufacturers and fabricators, covering the purchase by the latter of 1,000,000 tons of iron concentrate and partial financing of production at Silver Standard's Harriet Harbour iron-ore properties, on the Queen Charlotte Islands. The contract is subject to approval by a Sumitomo Mission consisting of the chief geologist, chief mining engineer, and a senior mining engineer, who will examine the properties in January.

Alscope Explorations holds high hope of successful drilling by the Richfield Oil Co. on the extensive holdings on the Queen Charlotte Islands, in which Alscope holds a substantial interest. The company also holds an agreement with British American Oil Co. covering 96,760 acres in south-western Saskatchewan. Formal notice of full patent rights on all Alscope's claims in connexion with its process for the manufacturing and preparation of alloys has been received from the United States and registration has also been filed in West Germany, Great Britain, and Canada. The company holds title to 32 claims in the Highland Valley and the Lynn Creek zinc mine near North Vancouver and a 90% interest in nearly 5,000 acres of oil leases near Fort St. John, all in British Columbia, uranium-bearing claims extending over 1,500 acres in the Beaverlodge area of Saskatchewan, and the Reid Lake lithium property east of Yellowknife, N.W.T.

Bridge River.—Renewed activity in the lower Bridge River valley has been assured through the acquisition by Bralorne Pioneer Mines of an option to purchase the 51-claim group of the Ace Mining Co. The claims were staked by Mr. Ernie Howard, a well-known prospector, and extend for 3 miles from Gun Creek to a point a mile east of the Wayside mine, containing the entire Congress mine property within the holdings. Terms call for minimum work performance by Bralorne Pioneer and, if the property is brought into production within specified limits, the optionee will earn the right to 60% of any profit accruing after return of pre-production expense. If the property becomes a small producer the ore will be trucked to one of Bralorne Pioneer's two mills in the upper valley. However, Mr. Howard is confident sufficient ore will be found to warrant the construction of a mill on the Ace ground. Several operating companies sought to make a deal for the property, on which a vein system has been exposed about 3,000 ft. from the Congress main portal. In one exposure a width of 4 ft. was stripped for a length of 37 ft. with average grade of 0·86 oz. of gold and 0·84 oz. of silver per ton with 0·42% arsenic and 0·34% stibnite. A new vein has recently been discovered close to the Congress main portal ; seven grab samples over a 4-ft. width have assayed between 0·5 oz. and 1·65 oz. of gold per ton for a length of 20 ft. The Ace company is capitalized at 5,000,000 shares of a par value of 50 cents each. Of this 1,000,000 shares have been issued for properties and 100,000 shares have been sold for cash.

Nicola.—Control of Torwest Resources has been returned to Vancouver interests after the Mogul Mining Corporation failed to exercise its stock options and continue development of Torwest properties.

Greenwood.—The balance sheet of Farwest Mining, Ltd., at August 31, 1959, lists cash and accounts receivable of $19,943 against current liabilities of $1,989. In the past year the company has engaged in exploration in partnership with Bethsaida Copper Mines and Northlodge Copper Mines, on the basis of 40% of the cost being borne by Farwest and Bethsaida and 20% by Northlodge. A thorough study was made of the possibility of locating extensions to the ore-bodies of the Union mine at Grand Forks, but the cost of the essential underground development is considered beyond the company's financial scope. An option on 32 claims

at Greenwood will be dropped unless activity develops in that camp in the near future. Further work will be done on the Owen Lake precious and base-metal property south of Smithers. Disappointing results were obtained in a geophysical survey of a prospect on the Adams Plateau. Eight claims at Sarita River on Vancouver Island are to be retained for investigation after logging in the area has cut down the trees. The exploration group is optimistic over two Ontario properties, a 22-claim copper prospect at Pancake Lake in the Algoma District and an iron property 4¼ miles from Lake Superior. In Yukon Farwest holds a $\frac{3}{13}$ interest in Yukon Oil and Gas Syndicate. The company during the past year invested $50,000 in Lake Central Mines to assist in the development of a gold-silver-lead-zinc property near Denver, Colorado. The property is reported to be close to the producing stage, but further funds are required before this goal can be obtained. The Farwest report states several alternative plans for financing are being studied.

Nelson.—During the six-month period to October 31 last Canadian Exploration, Ltd., earned a profit of $77,300, which compares with a loss of $138,000 in the same period of 1958. Production from the lead-zinc mine at Salmo, with figures for comparable periods of 1958 in brackets, for the quarter ended October 31 was 7,718 (8,367) tons of concentrates after treatment of 79,035 (85,854) tons of ore averaging 2·5% (2·6%) lead and 4·3% (4·4%) zinc. For the six-month period production was 15,080 (18,415) tons of concentrates from 157,837 (189,888) tons of ore grading 2·6% (2·7%) lead and 4·2% (4·3%) zinc.

Ainsworth.—Western Mines, Ltd., earned a profit of $569 in the 18-month period ended September 30, 1959. Since the end of the period the company has been carrying out its own development work and shipping ore. Recent development at the Lakeshore property has opened a replacement ore-body 14 ft. wide with grade of 6½% lead and 3¼% zinc. This zone was not previously disclosed by drilling.

Revelstoke.—All assets of American Standard Mines have been transferred to Consolidated Standard Mines and shareholders of the former company are to receive one share of Consolidated for each three shares of American surrendered. The extraordinary meeting also approved transfer of the company's option to purchase the River Jordan lead-zinc prospect near Revelstoke to a new company, Jordan Mines, Ltd. Consolidated Standard is to undertake exploration of a molybdenite prospect on Hastings Arm, north of the former Anyox camp.

Golden.—During the six-month period to November 30 last Sheep Creek Mines earned an operating profit, before write-offs, of $205,026, equivalent to $2·12 per ton of ore milled. The mill treated 90,675 tons of ore grading 2·69% lead and 4·59% zinc and produced 3,375 tons of lead concentrate with a net smelter value of $407,271 and 6,167 tons of zinc concentrate with a net smelter value of $263,290. The company also produced from the Mineral King mine 5,927 tons of barite valued at $44,393 to bring the net value of all production to $714,954. Miscellaneous income was $15,845. Operating expense aggregated $509,928 and capital expenditure amounted to $11,314. Results of development on the new low level of the La Reforma mine in Mexico have proved disappointing after the very encouraging results of early investigation.

EASTERN CANADA

January 20.

Gold Production.—During November the 30 producing gold mines of Ontario milled 770,437 tons of ore and recovered 227,176 oz. of gold and 35,262 oz. of silver, valued at $7,600,949.

Bancroft Area.—In the year ended July 31 last Canadian Dyno Mines treated 381,750 tons of ore and produced 452,636 lb. of uranium oxide, valued at $4,799,155. Operations resulted in a working profit of $1,448,387, but after all allowances the company suffered a loss of $1,699,342 in this its first full year.

Manitoba.—A 200-ton a day concentrator is planned for the Bernic Lake mine of Montgary Explorations, Ltd. It is reported that hand-picked ore is already being shipped from this cæsium-lithium property.

In the three months to September 30 last Sherritt-Gordon Mines earned a profit of $1,568,521. At Lynn Lake the mill extensions have been completed and 3,000 tons daily are now being handled.

Quebec.—In the year to June 30 last the Merrill Island Mining Company produced 7,357,729 lb. of copper, 1,218 oz. of gold, and 59,075 oz. of silver, worth $1,520,125. Operations resulted in a profit of $482,714. This was the first full working year for the company.

It is reported that drilling at New Hosco Mines has revealed two zones of copper mineralization. The company's ore reserves are now estimated at over 2,000,000 tons, grading some 2·5% copper.

AUSTRALIA

January 20.

Search for Oil.—The outstanding interest in Australia continues to be the search for oil, which was given new impetus by the discovery of a heavy gas flow at Port Campbell, Victoria, in a bore being drilled by Frome-Broken Hill, Ltd. This company has been making geophysical surveys of a basin extending from south-eastern South Australia to and eastward of Port Campbell, in Victoria, over a period of six years, and the present bore site is the first selected as a result of this work. The gas flow was met at a depth of 5,556 ft. to 5,666 ft. and was flowing at the rate of 2,000,000 cu. ft. per day under a pressure of 1,500 lb. per sq. in. The gas is petroliferous and is considered by the Chief Government Geologist of Victoria as one of the most significant oil-gas discoveries in Australia. Tests are in progress, directed to assess the quantity rather than the quality of the gas. The possibility of a nearby source of oil cannot be precluded and further exploration after the well has been thoroughly tested is warranted.

The South Australian Government plans an extensive search in the central part of the State, to be commenced in March. Plans are for a 600-mile traverse, east and west, along what is known as

"The Birdsville Track" extending from Birdsville to Marree and with east and west extensions from this line. Possibilities of this line have been considerably strengthened by the deep bore put down at Innamincka. The exploratory work will be seismic. South Australia contains three basins in which sediments of the right type and age occur. These are the Eucla basin, on the Western Australian side, where some water bores have been put down, the Great Artesian basin, and the Murray River basin. The Great Artesian basin, explored to some extent by water bores and latterly by bores directed to oil search, based on geophysical work, is known to contain wet gas and the problem is to locate a structure which will favour the accumulation of oil. The Murray River basin in the eastern and south-eastern part of the State extends into Victoria and the recent discovery at Port Campbell is in the eastern sector of this basin.

Drilling is in progress at Thangoo, 70 miles south-west from Broome, Western Australia, at Cooroorah, inland from Rockhampton, Queensland, at Betoota, in Queensland, near the South Australian border, at Madura, in Western Australia, and at Barikewa, in Papua. Drilling is also in hand at Spirit Hill in the Northern Territory and at Camden, near Sydney, in New South Wales, where gas in encouraging quantity has been tapped. The latest exploratory project is in the Rawlinson Ranges in the far north of South Australia, close to the border of that State and Western Australia.

Beryl.—A young industry that was assuming some importance was the production of beryl in Western Australia. Carried on by miners and working parties, as known occurrences have so far not justified the introduction of capital, the centres of production were the Pilbara mineral field, Onslow, and Carnarvon, in the north-west of the State, although some is produced in South Australia. The Australian Atomic Energy Commission is the sole buyer and has been purchasing over the past ten years, but it has just announced suspension of purchasing. This is a blow to the small industry, which was worth about £A45,000 per year.

Uranium.—At Coronation Hill exploration from No. 1 adit has disclosed a length of 82 ft. and a width of 46 ft. of ore, assaying 10·40 lb. uranium oxide per ton and 5·04 dwt. gold. Work to determine whether the gold can be economically recovered is in hand. Exploratory work is proceeding on the orebody at depth.

Mount Isa.—Disposal of Mount Isa Mines production of copper concentrates for 1960 is now assured under a contract with Japanese buyers, estimated at £A4,000,000. Grade of the concentrate is 25% copper and the long-term contract covers the purchasing of 72,000 tons of concentrates.

Mount Isa is active in the mineral exploration field. Considerable areas of mineral-bearing country have already been examined. Immediate future activities will be directed to areas in Northern and Central Queensland, as soon as the ending of the wet season permits travel in the back country and geologists and drillers to move. Five areas have been selected. In the Chillagoe district, once an important silver-lead-zinc and copper producer, tenders have been invited for drilling four exploratory holes to depths of 350 ft.; the company holds a concession of 9 sq. miles in this locality. Other areas are held under authorities of 39 sq. miles at Ingham, and 9 sq. miles near Rockhampton. The Mount Leyshon ore occurrence near Charters Towers has been secured by rights over 4 sq. miles. Mount Leyshon has been regarded rather favourably in the past and its possibilities may now be fully assessed.

It is probable that the Kangaroo Hills tin-bearing area, containing the once-rich Sardine tin mines, may be included in the search. Tin is becoming increasingly scarce in Australia, while the demand for the metal is increasing steadily. The tinplate works of the Broken Hill Proprietary Co. will probably be extended and at the present time the country's production of tin is well below requirements.

New Guinea.—The Territory of New Guinea has now introduced Income Tax, which will be levied under Governmental Ordinance from July 1, 1959. Earnings from the production of gold will, however, be exempt as is the case in Australia, but the full effect upon company operations in New Guinea is being carefully studied.

Tin Producers Association.—At the annual meeting of the Australian Tin Producers Association at Launceston, support was given to the Federal Council of Tin Producers in its endeavour to get taxation relief for producers on the same basis as gold. Australia is now importing large quantities of tin and it is a matter of national economy to consider measures of relief sufficient to encourage the search for and the production of tin in this country. In general tin has been an unpopular metal and many of the lode-mining companies formed have been inadequately capitalized with the result that, with the exhaustion of the shallow ore-shoots, there were insufficient funds available for the necessary exploration both at depth and laterally and shareholders were usually unwilling to subscribe further capital. This has resulted in the closure of mines that warranted active and well-directed exploration. There is scope, too, for the thorough exploration of some of the more important tinfields that were producers in earlier years. The Australian demand for tin has increased substantially and the potential resources of the country have not yet been adequately examined.

Fiji.—Emperor Mines has redesigned its treatment plant and it is expected that it will be in operation before the end of the financial year. The main benefit to be obtained from the reconstructed milling plant will be reduced costs, but with an efficient and well-designed mill the company might be able to increase throughput. Current production from the mine is being maintained at nearly the same level as last year, when a record of over 75,000 oz. of gold was recovered from 180,766 tons of ore; last year's figures should at least be equalled. There has been trouble with a heavy inflow of water at No. 15 level of the internal shaft, but this will be overcome by a special grouting pump. When the water trouble has been overcome the cross-cut at that level will be extended toward churn-drill holes where ore occurrences previously indicated should be confirmed and fuller information obtained about the extent and values of ore in the eastern area of the leases. Ore reserves are estimated at 862,000 tons of measured ore with an average grade of 8·7 dwt. and 330,000 tons of indicated ore with a grade of 8·5 dwt. per ton. The estimate does not include any open-cut ore, of which the tonnage is regarded as considerable, but further work is needed to prove the extent and grade. Prospects in the Crown-Crescent lode are considered

good and the lode should provide payable ore for some years.

Drilling Subsidy.—At the annual meeting of the Chamber of Mines of Victoria the president strongly advocated subsidies by the Commonwealth Government for diamond drilling and exploration for gold. He stated that Victoria offers areas likely to respond to vigorous exploration. The future of the gold-mining industry of the State depends on discovery of concealed orebodies which could be found by extensive drilling on the foundation provided by geological study. Success on any one area would entirely justify Government expenditure in assisting projects of this type. Drilling for oil is already subsidized and there is a good case for similar policy toward gold. It was considered that gold mining is sufficiently important to the economy of the country to justify subsidizing on a £ for £ basis for any exploratory work necessary to establish new mines.

WESTERN AUSTRALIA

January 4.

The Edwards Roasting Furnace.—Old timers will be aware that the years round about 1900 and " the turn of the century " were testing times on The Golden Mile, when numbers of experiments were being made to achieve improvements in the " extraction " from the so-called " refractory ores ". The London and Hamburg Company, Dr. Diehl, Sulman and Picard, and others were connected with experiments on the Brown Hill and Lake View Consols mines. South Kalgurli put in the Riecken process and for a time Great Boulder pinned its faith on the Konneman process ; there were others. It was also realized that roasting the ores to break up the sulphide particles as well as to discharge the sulphur would have good effects and some form of furnace was included in each of the treatment plants that were erected. Even so residues were invariably high. Some of the mines had adopted the expedient of shipping away the rich parcels for smelting and some again continued this when it came to the " sulphuress " or concentrates obtained from the Wilfley tables. Furnaces in general use at this time would have been Mertons, Holtoff-Wethey, the Ropp straight line, or Brown straight line, and many modified versions.

About 1899 Richard Hamilton (of Great Boulder) visited Ballarat to see the furnace that was at that time coming under notice—the Edwards. Edwards had been connected with gold mining in Victoria for a number of years and had spent many years on experiments with sulphide ores from which he had developed this furnace. Some furnaces were ordered for Great Boulder and in 1900 were being placed in position. Early in 1900 the furnace was being advertised (in the Kalgoorlie *Miner*) under the name of A. S. Lilburne, as sole agent in Western Australia. The furnace was claimed " to give a sweet roast " on all Golden Mile ores. At about the same time the Moss Brothers (Frank and Edward) had also been interested in furnaces of this type and were to become closely associated with treatment operations in Western Australia for a number of years. Under the joint auspices of Great Boulder and Moss Brothers the Edwards furnace was thus introduced to Western Australian metallurgical practice.

The first Edwards was a " simplex " with a single line of rabbles down the line of the furnace, which had an adjustable slope arrangement for the hearth by which the time of passage of the ore through the furnace and the tonnage was governed. A later furnace was the " duplex " with two lines of rabbles run in parallel fashion down the furnace and three fire boxes. Local conditions varied, for in some cases the amount of sulphur in the ore would be 30% to 40%, whereas in others it would be from 3% to about 5%. Tonnage in the earlier types of furnace might reach as much as 25 tons per day, whereas the " duplex " with its many modifications could account for as much as 100 tons.

Treatment on The Golden Mile in the last two decades has been along the lines of flotation and recovery of almost the entire sulphide content in a flotation concentrate ; this still goes to roasters of the Edwards type although with considerable modification to meet present-day conditions.

FAR EAST

January 12.

Tin Industry.—The Government of the Federation of Malaya has stated that because of the increase in the country's permissible export of tin concentrates all mines which were operating between January, 1953, and December, 1957, are to be allowed to resume operation. Permissible sales for the Federation's 8,000 dulang washers has been raised from 15 katis to 20 katis each month.

According to a report from Ipoh, Mr. A. W. Burne, Senior Inspector of Mines (North Zone), said that his section had informed 93 mines that he had been authorized to permit them to resume operations. Of these, he said, 41 had given notice of their intention to restart. Provision has been made for allocation of quota to these mines.

Tongkah Harbour Tin.—Shareholders of Tongkah Harbour Tin Dredging, Ltd., were informed at the annual meeting in Kuala Lumpur that plans made for financing the building of a sea dredge had been upset by present circumstances. Funds to the order of nearly £47,000 in the form of contributions to the Buffer Stock were still being collected and recourse to temporary finance from their bankers to cover the final outgoings for the completion of the sea dredge had therefore been necessary. The chairman said the sea dredge was about to be towed to Bhuket, Thailand, where it would undergo machinery tests and operating trials in the outer harbour leases prior to commencing productive operations. The company's application for the allotment of quota was at present being considered by a special assessment committee appointed by the Department of Mines in Thailand.

Pakistan.—Prospecting for iron ore began recently in new areas of West Pakistan at Kalabagh, where tunnelling work is in progress. Meanwhile good-quality iron ore has been reported from Waziristan and small deposits found near Muzaffarabad, in Azad Kashmir.

Deposits of china clay are reported to have been found along the Salt Range in West Pakistan. Samples studied at the West Regional Laboratories have shown the clay to be of good quality. The deposits are in a good position for mining, it is stated, and are approachable by road and rail.

An agreement has been formally signed between the Pakistan Government and four oil companies—Shell, Caltex, Burmah, and Standard-Vacuum—for the setting up of a petroleum refinery near Karachi. It will cost about Rs. 165,000,000 and will take two-and-a-half years to build on a 300-acre site six miles east of Karachi. When in operation it is expected to save some Rs. 315,000,000 annually in foreign exchange. Under the agreement Pakistan will be associated with the refinery's management. A large number of young Pakistanis are to be trained in refinery techniques to enable them to hold responsible positions at the new plant.

A steel smelting plant to be set up at Chittagong, East Pakistan, will have a production capacity of 12,000 tons a year, while a plant expected to be built near Karachi within two years is planned to produce about 75,000 tons annually.

China's Mineral Resources.—On the basis of geological data so far obtained it is now estimated that China has iron-ore deposits of more than 100,000,000,000 tons, while coalfields of good quality have been discovered in Kwangtung, Hunan, Fukien, Chekian, and Kiangsi provinces. It is reported that China now has 330,000 geological workers, including 48,000 trained engineers and technicians.

India.—The Indian Government is to set up a central designs organization which will plan and design public steel plants. A nucleus, with an Indian chief design engineer and 30 other young design engineers, has already been created at Rourkela. A study is to be made of the three plants of Rourkela, Bhilai, and Durgapur with a view to planning their expansion.

Investigations carried out by the Geological Survey show that 21 seams of coal with a total reserve of 188,000,000 tons have been located in the South Karanpura coalfields of Bihar State. Of these three are stated to be of considerable thickness and capable of yielding about 12,000,000 tons of coal. The existence of two new workable seams of coal in the Jarangdih colliery area, east of Bokaro, and Chirmiri coalfield in Madhya Pradesh has been proved by the Indian Bureau of Mines.

SOUTHERN AFRICA

January 28.

The South African Foundation.—With the objects of " promoting international understanding of the South African way of life, its achievements and aspirations, and international understanding and recognition of the country's contributions and support for European civilization on the African continent ", and of mobilizing leaders of industry, commerce, and culture in a non-political and non-Government drive to present a true picture of South Africa, including the economic and investment aspects, the South African Foundation has been established. Members include Sir Frederick de Guingand, as chairman, Dr. H. J. van Eck (chairman of the Industrial Development Corporation), Dr. J. E. Holloway (formerly the Union Secretary of Finance, Ambassador in Washington and High Commissioner in London), Dr. M. S. Louw (chairman of the Federale Mynbou), and Mr. C. W. Engelhard, as vice-chairman. Mr. Engelhard is chairman of the New York committee and Sir Frederick de Guingand organizer of the U.K. Committee in London. Members of the provisional Board of the Foundation include Mr. H. F. Oppenheimer, Mr. R. B. Hagart, Mr. T. Stratten, Mr. S. G. Menell, Mr. C. S. Barlow, Mr. A Berrill, Dr. M. H. de Kock, Dr. F. J. du Toit, Mr. G. H. R. Edmunds, Dr. F. Meyer, and Mr. E. Rossouw.

Diamonds.—With its direct activity in marketing industrial diamonds in the United States restricted by the anti-trust laws, Industrial Distributors (1946), Ltd., of the De Beers group recently concluded arrangements with Engelhard Industries, Inc., of the United States whereby the latter establish a specific division for holding stocks and effecting sales of industrial diamonds in major centres of the United States. Research into the extension of the application of diamonds to grinding is also to be conducted.

Training Scheme.—Reflecting the continued shortfall in the gold-mining complement of certain categories of skilled personnel, the Chamber of Mines, particularly on behalf of its gold-mine members, has introduced a new scheme of training, intermediate between apprentice and university status, for learner-officials (mechanical and electrical). The training of the learner-officials includes practical work on the mines and 4½ months each year for four years at the Witwatersrand Technical College, and a further two years' training in a Pupil Engineer's Course, after which the trainee can sit for the Mechanical and Electrical Engineer's Certificate of Competency. In addition to the free course of training the trainee will be paid on a rising scale *plus* full cost-of-living.

Metallurgical.—Two outstanding benefits of centralized research into metallurgical problems have been reported by the Anglo-Transvaal group. Evolved in the programme of research is the " reverse leach " process in use at the Hartebeestfontein mine, where the uranium extraction is followed by gold recovery, with improved yields in both cases. At the Virginia mine the " hot ferric leach " has improved the uranium yield.

The central laboratory has also evolved a process for the economic concentration of nickel from ore of the group's Southern Rhodesian deposit.

Exploration.—The Transvaal and Delagoa Bay Investment Co., in association with Portuguese interests, has formed an exploration company in Lourenco Marques for operations in the northern and central districts of the territory. The company has also initiated a drilling programme to re-assess its coal holdings in the Wakkerstroom area of the Transvaal, where it has secured options over an adjoining 4,220 acres, the coal deposits of which will also be explored. In its Eastern Transvaal colliery mechanization has been extended further to an extent enabling the colliery to regulate output according to the normal fluctuations in orders, rail truckage, and the availability of native labour. The company attributes the 1959 recession in coal sales to the reduction of excess stocks by such consumers as the railways, power stations, and certain industries, to the mild winter, and least of all, the lower industrial activity. Sales in 1960 should be comparable with 1959 levels.

In respect of its Lourenco Marques concession the company has now reached full agreement with the Portuguese authorities for the establishment of an industrial and residential township on a portion of its concession. The company's substantial investments in new mines of the Far West Rand, the

Klerksdorp area, and the Free State goldfields is yielding steadily improving dividend income. The major portion of the general reserves is being capitalized by the issue of two bonus shares for every one share held.

Transvaal.—Full-scale sinking operations are now proceeding in the sub-vertical shaft of Buffelsfontein Gold Mining, in the north-western section, while preliminary operations are in progress at the site of the projected shaft in the eastern section. The gold plant capacity is being expanded to 200,000–240,000 tons a month.

Apart from operations on the Kimberley Reef horizons, where results continue to be satisfactory, both Marievale Consolidated and Grootvlei Proprietary are apparently advancing much of the Main Reef development effort in zones of relatively lower grade, outside the recognized payshoot areas. This has been rendered possible by the satisfactory tonnages already developed on the Main Reef horizon in both mines. Kimberley Reef ore reserves are not yet being published, owing to the fact that development on that horizon has been in progress only a short while.

At East Rand Proprietary deep-level operations have now been extended into the extreme eastern section. The sub-vertical component of the Far East shaft system has intersected the Composite Reef at 8,897 ft. below surface and a small footage sampled averaged 126 in.-dwt., while immediately north of the shaft, in a payshoot zone, a deep-level cross-cut has intersected the same reef about 2,440 ft. from the shaft with values of 446 in.-dwt. over 46 in. Erection of the new gold plant proceeds near the Central shaft.

The African Metals Corporation, using domestic raw materials—such as, coal and tarpitch—has successfully produced graphite electrodes and other products on a small scale with very encouraging results. The Corporation has now entered into an agreement with an associate of the Siemens-Plania group for more extended tests of domestic raw materials, the results from which will determine the feasibility of establishing a factory at the Kookfontein works of the Corporation, near Vereeniging, with an output capacity of about 3,000 tons of electrodes a year. Present consumption of graphite electrodes, used in electric-arc furnace processes, is about 2,600 tons a year.

Ellaton Gold Mining, in which Eastern Rand Extensions is the major shareholder, has a life-expectancy of about only a year. Afrikander Lease, Ltd., the uranium contract of which expires at the end of 1964 and which has a sales quota of 177,800 lb. of U_3O_8 a year, will assume Ellaton's sales quota on the suspension of operations. Ellaton's sales quota is 123,200 lb. of oxide a year, terminating at the end of 1964. On these figures the sales quota of Afrikander Lease will rise to 301,000 lb. a year on the suspension of operations by Ellaton.

In the most southerly of the three bore-holes (drilled or being drilled) in the western section of Hartebeestfontein Gold Mining the Vaal Reef at 6,734 ft. disclosed 316 in.-dwt. and deflection results are awaited. In the second bore-hole, that to the north, three deflections have yielded 714, 602, and 15,317 in.-dwt. Results have not yet been released from drilling in the third bore-hole further north-west again. These results have considerably improved the long-term outlook for the mine and the deeper western section in particular, where disclosures have been below some expectations. While the possibility that the highest of the above results may be due to fault-enrichment cannot altogether be excluded, the effect on the overall grade to be expected now from the mine is marked. These bore-hole disclosures have also improved the outlook for Hartebeestfontein's western neighbour, Zandpan Gold Mining, especially in respect of its eastern section, where two bore-hole results were the subject of an official investigation.

The Associated Ore and Metal Corporation, which has acquired 400,000 additional Associated Manganese deferred shares through the latter's take-over of Feralloys, Ltd., has considerably extended its asbestos holdings in the Pietersburg area of Northern Transvaal, where, however, production has been temporarily suspended while accumulated stocks are being reduced. In the Potgietersrust area discouraging results from an investigation of one tin deposit has led to placing the mine on a care-taking basis, while in another, where substantial tonnages of tin ore are available, research for a suitable process of extraction is proceeding. Resumption of tunsten concentrate production in South-West Africa has not yet been considered justified. Commercial production of corundum abrasive wheels has been initiated in a recently completed plant.

Four quarries have been developed by the Phosphate Development Corporation (Pty.) with reserves of about 1,700,000 tons of phosphate rock, averaging about 10·5% P_2O_5, and the opening of a fifth is now projected. Hitherto, operations have been confined to higher-grade zones, but more recently these have been extended to investigating relatively lower-grade pyroxenite, with encouraging results, suggesting that the reserves may be such as to supply the country's requirements for many years. Modifications to the plant have improved the handling capacity and recovery and the throughput capacity is being expanded further by new installations now being effected. Field fertilizing tests have been conducted with calcium-magnesium phosphates with promising results.

Extensive coal deposits in the Waterberg area of the Northern Transvaal are being explored by diamond drilling by the South African Iron and Steel Industrial Corporation, Coal with coking qualities forms a considerable proportion of the deposits. To provide adequate samples for testing the coking qualities diamond bits to give a 10 in. core are being used.

Witbank Colliery completed its programme of mechanization in its 1958–59 year. To serve the area which will be worked over the next 12 to 15 years a new ventilation shaft is being sunk and will be equipped with a fan. A continuous thickener has been installed to deal with coal slurry in the washing plant effluent. The conveyor-belt haulage system, which replaced the endless-rope system, has operated satisfactorily.

Despite an unfavourable response from the directors of Witbank Consolidated Coal Mines to its take-over offer Henderson's Transvaal Estates is persisting in its bid. One of the main reasons for the persistence is Henderson's holdings of coal rights adjoining the Witbank Consolidated property, which appears to favour joint exploitation rather than the establishment of another colliery.

Orange Free State.—In its area of about 6,472 claims immediately south of the Vaal Reef's lease area, in which area 13 intersections of the Vaal

Reef horizon had previously been secured, Western Holdings, Ltd., recently resumed exploratory drilling. Relatively severe faulting in the area is indicated. East of the Western Holdings area drilling is being conducted jointly by the Free State Development and Rand Mines companies. Drilling has proceeded sufficiently to indicate the existence of at least one more mine in the vicinity of Klerksdorp. The Vaal Reef horizon is correlated with the Basal Reef of the Free State goldfield further to the south and with the Bird Reef of the Witwatersrand.

The programme ahead of President Brand Gold Mining Co., Ltd., briefly consists of increasing the number of stope faces in the lower-grade No. 2 Shaft area and extending operations there to depth, completing the sinking of the No. 3 Shaft system in the north-eastern section, and expanding the gold plant capacity to the 150,000-180,000 tons-a-month range. The greater tonnage to be drawn from No. 2 Shaft area will lower the mill grade to that more representative of the mine as a whole, which, after dilution with development ore, may be about 14 dwt. a ton.

More recently, operations at Welkom Gold Mining Co., Ltd., have been rendered somewhat difficult by relatively extensive methane-bearing areas, which restricted development to a limited number of ends. However, with the completion and commissioning of the No. 3 Shaft system in the south-western section, deepening of the other two shafts, increasing the number of ventilation connexions between workings, and in one shaft area expanding fan capacity, the way has been prepared for extension of workings and expansion of operations. This will be accompanied by increased milling and probably by an improvement in the grade and yield. Drilling results in the lease area indicate that the yield could perhaps be raised to the 8–9 dwt. mark especially with an intended increase in the surface waste-sorting rate, already at more than 11%.

One of the main features of operations at Free State Geduld Mines, Ltd., in the immediate future will be the re-organization of the ventilation facilities in the No. 1 Shaft area. To serve workings and their extension north of No. 1 Shaft airways will be cut to connect with the northern No. 3 Shaft and adequate fan capacity installed. This will mean mining greater tonnages of lower-grade ore, resulting in an overall grade more representative of the mine. Existing ventilation capacity at No. 1 with that to be provided by the ancillary ventilation shaft now being sunk to the south will facilitate an extension of operations west and south of the shaft to the common boundary with Western Holdings in a zone of exceptionally high values. With the completion of the No. 2 ventilation shaft an expansion of the southern operations and an extension of workings northwards and especially eastwards to and through a major fault-zone have been facilitated.

Trade Notes

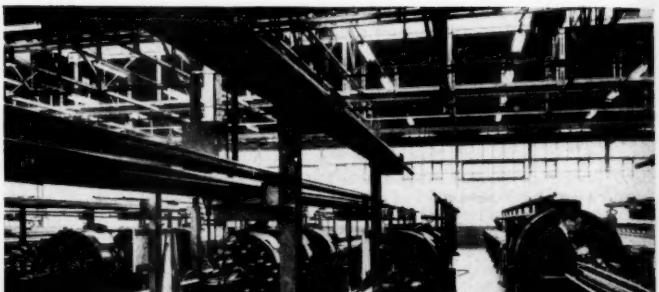
Brief descriptions of developments of interest to the mining engineer

New Hose Plant

A considerable extension to their factory, for the production of hose, at Castle Mills, Edinburgh, was recently brought into operation by the **North British Rubber Co., Ltd.,** which is affiliated to the U.S. Rubber Co., of New York. Last month a visit was made to the works by Lord Craigton, Minister of State for Scotland, and Sir Ian Johnson-Gilbert, Lord Provost of Edinburgh, to see the new plant. Industrial hose forms an important part of the company's output and there are many varieties made—such as, air hose (including rock-drill), water hose (including high pressure), suction hose (for water and sand), steam hose, oil and petrol, and chemical hoses. An illustrated catalogue gives particulars of these as well as of miscellaneous hoses and a variety of couplings and fittings for all purposes. In addition to the new hose plant the company's tyre manufacturing capacity has been doubled and the rest of the factory modernized and a new steam plant erected. Illustrated here is the braiding section, showing 24-spool and 36-spool braiders and take-away assembly. Some varieties of wire-braided hose will withstand pressures up to 6,000 p.s.i.

Oil-Resistant Tank Linings

Rapid deterioration of previous tank lining materials has led many operators of uranium reduction plants in South Africa to turn to neoprene. One of the problems has

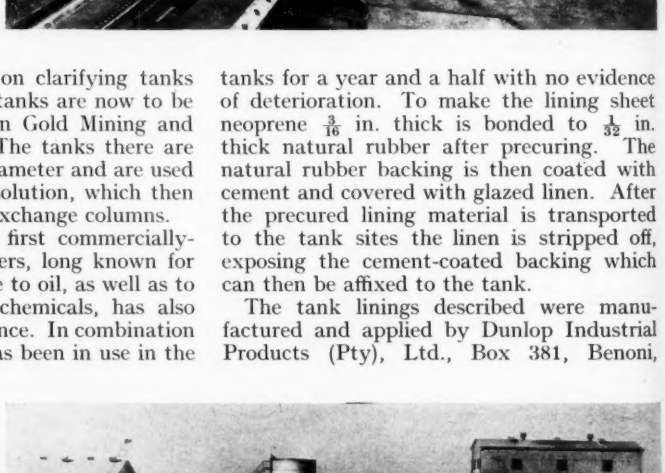


North British Rubber Company New Hose Factory.

been the attack by oil on clarifying tanks linings. Neoprene-lined tanks are now to be found at President Steyn Gold Mining and Welkom Gold Mining. The tanks there are 8 ft. high and 50 ft. in diameter and are used to clarify the pregnant solution, which then goes directly to the ion-exchange columns.

Neoprene, one of the first commercially-available synthetic rubbers, long known for its outstanding resistance to oil, as well as to a number of corrosive chemicals, has also excellent abrasion resistance. In combination with natural rubber it has been in use in the tanks for a year and a half with no evidence of deterioration. To make the lining sheet neoprene $\frac{3}{16}$ in. thick is bonded to $\frac{1}{32}$ in. thick natural rubber after precuring. The natural rubber backing is then coated with cement and covered with glazed linen. After the precured lining material is transported to the tank sites the linen is stripped off, exposing the cement-coated backing which can then be affixed to the tank.

The tank linings described were manufactured and applied by Dunlop Industrial Products (Pty), Ltd., Box 381, Benoni,



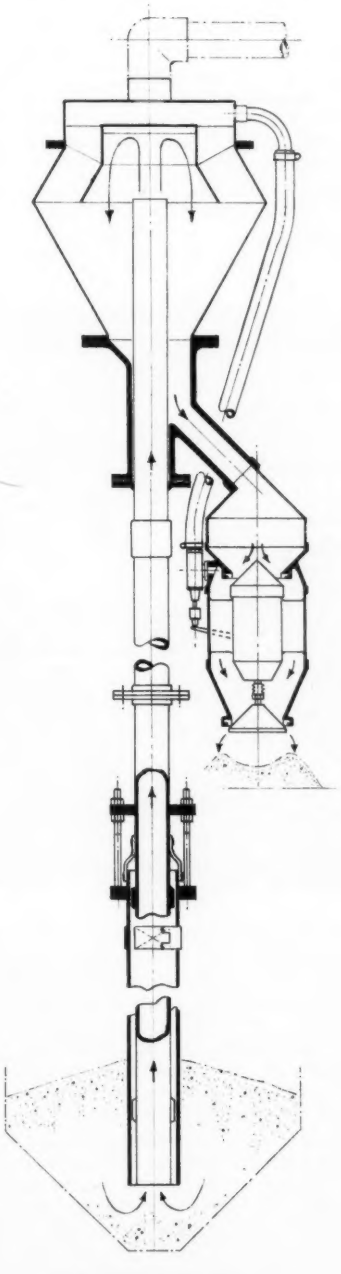
Neoprene-Lined Tanks in Uranium Plant.

Transvaal, this information being supplied by **E. I. du Pont de Nemours and Co., Inc.,** of Wilmington, Delaware.

Pneumatic Elevator for Sands and Heavy Minerals

Some interesting features are incorporated in an air lift designed by **R. O. Stokes and Co., Ltd.,** of 529, Salisbury House, London Wall, E.C. 2, for a convenient and easy control of fine mineral sands. A number of these devices have been used in recent years, in conjunction with electrostatic separators, for the re-circulation of middlings products. The apparatus, shown in the figure, consists essentially of two main parts—that is, the tail end, where fluidized sands are first drawn into the ascending tube, and the head end, which comprises the sand trap and air lock. The two ends are connected by a pipe of the necessary height and size to pass the tonnage required. The whole system is under vacuum from an exhauster and the connecting pipe is shown at the top. At the lower end are two tubes, one within the other, the outer tube being adjustable in height by means of draw bolts. According to the condition of the sands, so is the outer tube raised or lowered to give maximum flow within the centre tube. Further, an air control is provided in the outer tube which may likewise be regulated and it is the incoming air at this point which fluidizes the sands.

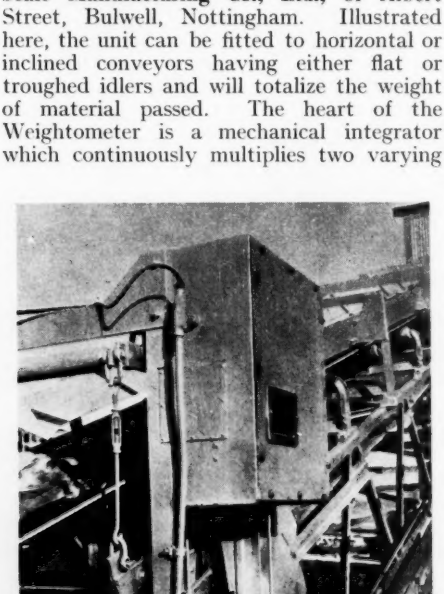
The elevated sands are discharged into the sand trap from where they may flow by gravity to a mechanical air lock. Within this device two conical valves and an intermediate chamber are situated. The valves are operated by a small motor and timing device, so that the upper or inlet valve can only be opened when the lower or discharge valve is closed. This enables the sand to enter the intermediate chamber, after which the inlet valve will close and the outlet valve open and discharge to atmosphere. As the entire system is under a slight vacuum, a separate by-pass valve is provided to connect the intermediate chamber to the top of the sand trays. The automatic operation of this valve primes this chamber to the working vacuum so that the back-flow of air passes through a separate pipe and does not impede the downward-flowing solids from the sand trap.



Pneumatic Elevator.

Belt Weighing Machine

Some particulars have been made available about a new belt weighing machine, known as the SV Weightometer, by the **Merrick Scale Manufacturing Co., Ltd.,** of Albert Street, Bulwell, Nottingham. Illustrated here, the unit can be fitted to horizontal or inclined conveyors having either flat or troughed idlers and will totalize the weight of material passed. The heart of the Weightometer is a mechanical integrator which continuously multiplies two varying



quantities, which are, first, the ever changing load on the conveyor, often subject to extreme and very rapid fluctuations, and, secondly, a slightly varying belt speed of the conveyor.

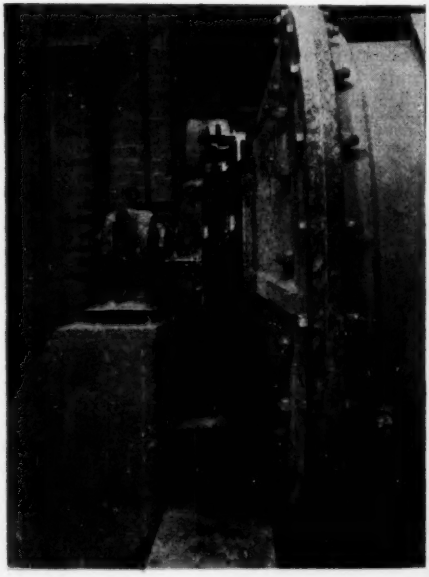
The speed of a conveyor, usually considered constant, in reality varies slightly with the load and in weighing, unless these conditions are taken into consideration, any final results will be erroneous. Both electronic and pneumatic types of instrumentation can be supplied with the machine and the recorder can be at a remote position if required. The accuracy of the Weightometer is *plus* or *minus* ½% of true weight passed when the conveyor is operating at full load conditions.

Overflow Grinding Mill

The development of an improved type of mechanical overflow grinding mill is announced by **Mitchell Engineering, Ltd.,** of 1, Bedford Square, London, W.C. 1. For certain purposes the overflow mill is preferred to the air or gas swept mill and it is to meet this requirement that the new tube-mill has been developed. It has semi-conical heads at each end, giving large trunnion openings. In the centre of the heads is positioned a boss which is connected to the head by means of arms, generally four in number. The arms are of robust section and inclined to the arms of the mill, so that on rotation of the mill they have a screw action.

At the feed end this action assists the movement of the material into the mill barrel and allows the maintenance of a high level of the material in the body. At the discharge end the reverse is true and all material passing the sieve plate is quickly discharged by an opposite-handed head. It should be noted that the whole diameter of the head is effective since the arms extend practically from the mill centre to the periphery.

With most sizes the body and heads are carried on stub shafts which are shrunk into the head bosses. The shafts are supported in large-capacity roller bearings which are grease lubricated. This method of assembly permits the fitting of generous feed and dis-



charge boxes, which allow almost vertical flow of material to and from the mill. They also enable fully-sealed bearings to be employed, grease packed instead of oil lubricated, and the elimination of cumbersome seals at the junction of the mill and bearing. Efficient seals are fitted at the junction of boxes and mill heads, which are easy to inspect and maintain. Extension of the stub shaft at one end enables a totally-enclosed gear drive to be fitted and this can, if desired, be placed in a separate house to preclude damage by dust from adjacent plant. Alternatively, the mill may be carried on rollers placed along the barrel and mating with riding rings.

The mill can be used for all types of overflow grinding and is a standard product. Thus only small modifications are necessary for changes from dry to wet grinding. Replacement parts, when necessary, can therefore also be ordered in full confidence as to fit and specification. Linings can be supplied as required—*e.g.*, silex, prodorite, granite, ferro-manganese bars, steel, etc. That recommended is a special cast steel, guaranteed for arduous duty and manufactured to rigid specification.

Personal

H. GEAR, assistant director of the World Health Organization from 1952 to 1959, has been appointed director of the Pneumoconiosis Research Unit of the South African Council for Scientific and Industrial research with effect from the beginning of 1960, in succession to Dr. A. J. ORENSTEIN, retired.

E. V. GREGSON is home from New Caledonia.

J. A. GRIFFITHS has been appointed a director of Ghana Main Reef, Ltd.

S. H. IRELAND has been appointed assistant managing director of the Consolidated Pneumatic Tool Co., Ltd.

J. D. MCCALL has been appointed a director of the Anglo-French Exploration Co., Ltd.

R. B. MCCONNELL is returning from British Guiana.

RICHARD MILES, chairman and managing director of Head Wrightson and Co., Ltd., has retired and Sir JOHN WRIGHTSON, Bt., vice-chairman and managing director for the last ten years has been appointed to succeed him.

COLIN RAEBURN, formerly Director of the Nigerian Geological Survey, was created Knight Bachelor in the New Year Honours List for services in Cyprus.

GEORGE C. REYNOLDS is home from South Africa.

JEAN VUILLEQUEZ, vice-president of American Metal Climax, Inc., has been elected president, chairman of the board of directors, and chairman of the executive committee of the Lead Industries Association in New York.

N. W. WILSON is home from Sierra Leone.

Metal Markets

During January [1]

Copper.—For something like the eleventh or twelfth month in succession consideration of the January copper scene must refer to strikes in the U.S.A. Against all probability the three big U.S. producers—Kennecott, Anaconda, and Phelps Dodge—have remained strikebound throughout January, although, as the month closed, Kennecott reported final settlement with three minor unions, some weeks after settlement had been reached with the major union. Phelps Dodge and Anaconda seem on the verge of returning to work too.

As a result of this the pressure on the spot copper position has tended to intensify and prices have touched a peak of £270 per ton.[2] In the face of the certain knowledge that world 1960 production is bound to exceed consumption by quite a margin, however, the market has retained a nervous background. This has been reflected, too, in the backwardation in prices which has at times reached £20 per ton. This aspect of the situation was intensified when the world copper figures of the U.S. Copper Institute for 1959 were released. These showed that, despite the loss of production through the U.S. and Chilean strikes, world copper output in 1959 was probably slightly higher than in 1958 and still above consumption, even though the latter was improved.

The question of how soon the present spot squeeze will be alleviated is, therefore, the key one at present. The last-minute news that Kennecott at any rate expects to be able to resume production on virtually full scale within a startlingly short time has rather revised some estimates in this respect.

After a year of bitter competition and low operating rates the wire rolling industry here was heartened in January by the receipt of an order for 25,000 tons of copper wire rods for China. Consumption figures show that, through the loss of this useful 1958 outlet, U.K. 1959 offtake was some 64,000 tons lower. On the home front there are hopes that copper consumption will benefit from a buoyant economy in 1960, although there have been one or two dampening reflections on this prospect, not least the increase of 1% in the U.K. Bank Rate.

While the fluctuations in London prices have, as noted, been nervous and therefore unpopular with users of the metal, the situation here has at least not been as bad as in the U.S.A., where users have been asked almost 40 cents per lb. (£320 per ton) for spot imported electro copper. U.S. 1959 raw copper imports may have touched the 400,000 tons mark mostly as a result of the strike.

Consumption in the U.K. in November was 60,855 tons, of which 47,031 tons was electro. Production of primary refined was 8,996 tons and secondary refined 9,206 tons. Stocks of blister copper were almost unchanged at 10,624 tons, but those of refined dropped to 50,312 tons.

Tin.—Tin has been firmer than some people expected in January.[2] It had been argued that the knowledge that world supplies were at the higher level, made possible by the first-quarter 1960 export quotas for producing members of the International Tin Agreement, would have a depressing effect on

[1] Recent prices, pp. 72, 120.
[2] See Table, p. 120.

prices. In fact, demand from all directions and noticeably from the U.S.A. was at strong levels in January. It is true that metal has been offered rather more freely in the Singapore market, but the fact remains that spot tin supplies in the world are no more than adequate to meet demand. As a result, although there have been rumours of Buffer Stock Manager action on the London Metal Exchange, it seems likely that this has still been on the selling rather than the buying side. Later on, of course, the bigger quotas may well be reflected in freer world metal supplies and there is no particular occasion for calling tin a buoyant market. Basically, however, the situation could show a greater approximation to balance in the next few months than was felt likely in the latter part of last year.

Tin consumption in the U.K. in November, 1959, was 1,841 tons with production 2,513 tons of new metal. Stocks moved up slightly to 10,545 tons.

Lead.—The position of both lead and zinc in January has been somewhat paradoxical. There has been no lack of fairly authoritative forewarning in the trade Press on the likely outcome of the United Nations lead-zinc meeting, which is being held in Geneva as this report is written. Most people are disposed to believe the reports which have been circulating for most of the month that, in the case of lead, the meeting will be followed by an announcement that the producing companies which are now restricting supplies to the market will maintain these restrictions up to the middle of 1960. However, there has been a strong inclination for prices [1] to mark time pending the official announcement, although it should be recorded that, if prices have not actually been strong during January, they have shown a greater resistance to the attacks of weakness, on a broad and sentimental basis, which beset the market in the latter part of last year. Consumption remains very fair.

U.K. November use was 32,579 tons, with production of English refined 7,872 tons and stocks dropping 10,000 tons to 46,984 tons.

Zinc.—As with lead, the zinc market has been somewhat as if in a state of suspended animation in January, pending an official pronouncement from Geneva. It should be made clear, however, that this announcement is only expected to make certain what is already believed—namely, that since the beginning of the year, the major producers who restricted supplies last year, have returned to full-scale marketing. In view of this, and of the possibility of further U.K. Government stock releases from time to time, the market has been soft in price as well as sentiment.[1] In the U.S.A. there have been some confusing developments in premiums for high-grade zinc, but generally the premium there is 1½ cents (£12 per ton) compared with £9 in the U.K.

U.K. zinc consumption in November was 29,221 tons. Production amounted to 5,608 tons and stocks were very slightly lower than at the end of October, at 35,460 tons.

Iron and Steel.—The year has begun very briskly for the British iron and steel industry. Steelworks are now working up to 95% of capacity, order books are good, and the current rate of demand is expected to be maintained for the first half of the year at least. The main interest is still chiefly for the lighter range of steel products. Sheets are very tight indeed and there is also a lively demand for small bars and sections, strip, wire, and special steels. Delivery dates for these products are fairly extended and there is a tendency for them to lengthen still further. A feature of this market is that consumers are ordering material for stock.

The heavy steel trade, although much brighter than a few months ago, is still overshadowed by the uncertain prospects of three of its major customers—shipbuilding, coal mines, and railways. However, there is an improved rate of demand from other heavy steel users, including heavy engineering, capital plant manufacturers, the heavy pipe mills, and structural engineers.

British exports of iron and steel in 1959 increased by 10·7% to reach 3,100,000 tons. The U.S. steel strike had a marked effect on the world export market last year and Continental mills, by turning their attention to the U.S.A., relieved competitive pressure on other markets, enabling British mills to increase sales there.

The outlook for the U.K. steel industry this year is very promising. Given the demand production should reach 24,000,000 ingot tons, while there will be enough capacity for an even higher figure to be attained.

Iron Ore.—Production of domestic iron ore, the intake of foreign material and consumption are all at a higher rate. The increased rate of steel production has raised the melting shops' requirements of blast-furnace metal. A tightening of scrap supplies in this country foreshadows the relighting of more furnaces. Imports of iron ore last year reached 13,300,000 tons, which was 3% more than 1958, but below the record 1957 total of 15,900,000 tons. Sweden remained the biggest supplier with over 3,100,000 tons, followed by Canada with 2,700,000 tons, while Algeria and Venezuela supplied over 1,400,000 tons each.

Aluminium.—By acquiring a 50% interest in James Booth Aluminium, as announced midway through January, Kaiser Aluminum and Chemical Corporation has done what many observers have been expecting it to do ever since the Reynolds/T.I.-British Aluminium take-over battle a year ago; it has joined its fellow United States aluminium-producing giants in securing a firm foothold in Britain's fabricating industry.

With a surplus of the metal in recent years the major producers have been seeking for some time past to obtain every possible outlet for themselves. Kaiser's entry into the U.K. fabricating industry now means that all four of the world's major producers—namely, the Aluminum Company of America, Reynolds Metals, Kaiser, and the Aluminum Company of Canada (a subsidiary of Aluminium, Ltd.)—have a stake in the British market. The Aluminum Company of Canada (Alcan) has, of course, had an important outlet in this country for many years in Northern Aluminium, which produces about one-third of Britain's total yearly output of fabricated aluminium products. Reynolds Metals has had a stake since 1957, when it bought a half interest in the aluminium side of the Tube Investments group. Then, about a year ago, it won control of British Aluminium—which then produced something like a further one-third of Britain's total output of fabricated aluminium products—after what is now looked on as a historic battle with the Aluminum Company of America (Alcoa). Not to be entirely outdone, Alcoa subsequently joined with Imperial Chemical Industries

[1] See Table, p. 120.

in establishing Imperial Aluminium last summer. At about the same time certain observers began drawing attention to the fact that James Booth and Company was one of the very few existing fabricating concerns in this country of any real significance still open to the possibility of U.S. participation. Just before Christmas it began to look as if their suspicions might be confirmed when the chairman of Delta Metals, which then controlled the Booth company and which is now associated with Kaiser in the new venture, said that his company and Kaiser would soon be announcing details of an arrangement to their mutual benefit. The present plan, whereby both will contribute £5,000,000 to finance James Booth Aluminium's development and expansion, is the outcome of their discussions which began early in December.

With all three major U.S. aluminium companies now represented by fabricating organizations in this country the future looks like being one of even stronger competition than hitherto for sales in a market where prospects are improving steadily.

Antimony.—In the U.K., which is rather insulated from the world market because of import duty, the price of English regulus 99·6% is again unchanged at £197 10s. a ton delivered, while 99% material continues to fetch £190. World competition in general—which has been so strong in recent years that Chinese and Russian material has been consistently finding its way into this country to sell at a discount, despite the imposition of a stiff import duty (now £40 a ton)—has recently shown signs of slackening, however, and prices have hardened accordingly. In the U.S., for example, prices for imported material have risen by as much as 1 cent a lb., although they are still in the region of 3 cents a lb. under the domestic price, which is currently 29 cents.

The U.S. has been importing more antimony recently than for quite some time past. According to the latest figures available imports in the third quarter (when domestic production was, of course, affected by the labour troubles in the mining industry) increased by about 15%.

Arsenic.—The market for arsenic was again featureless in January, with the metal quoted once more at £400 a ton. Arsenic trioxide was once more priced, as for some time past, at £40 to £45 a ton ex stock.

Bismuth.—The bismuth market has shown few new features in recent months and quotations were again unchanged throughout January at a nominal 16s. a lb. for ton lots ex warehouse.

Cobalt.—Marketwise there was little new to report on cobalt during January and the open-market price for delivered metal throughout the month remained unaltered at 14s. a lb. The U.K. contract price for delivered metal was also unaltered at 12s. 6d. a lb., while quotations for the black and grey oxides, delivered, remained at their December levels of 9s. 1d. and 9s. 8d. a lb., respectively.

Cadmium.—The American Smelting and Refining Company raised its U.S. cadmium price on January 7 to a basis of $1.50 a lb. at the same time as a certain shortage of European metal began to show itself. This move had no immediate effect on the U.K. price for U.S. material—then 10s. a lb., delivered—and, indeed, both foreign and Empire material were equally available at that price, against a background of a strong demand and a healthy market undertone. Belgian asking prices advanced subsequently, however, further underlining the strength of the market, although all other material in the U.K. remained quoted at 10s. a lb. for the rest of the month. Many observers feel that this may cause something of a withdrawal of U.S. supplies in the near future, since the return to the producer after deducting duty and freight would not be sufficiently attractive in view of the new domestic price.

Chromium.—Chromium metal prices were again steady at 6s. 11d. to 7s. 4d. a lb. throughout the month.

Tantalum.—Tantalum prices were also steady in January, 60% ore continuing to be quoted at 650s. to 700s. a unit c.i.f.

Platinum.—Demand for platinum is growing steadily and open-market material has become less freely available than of late, with the result that Johnson, Matthey and Co. and then Baker Platinum felt able to advance their selling prices for U.K. and Empire refined metal from £28 10s. a troy oz. to £30 5s. midway through the month. Open-market prices also advanced later in the month, this time to £28 10s. to £29 10s., against £27 5s. to £27 15s. previously. Most of the business transacted in open-market metal since the rise has been at about the middle of the range, though platinum of Russian origin has generally been on offer at slightly cheaper prices.

The other big event during January as regards platinum was, of course, the statement by the chairman of Rustenburg Platinum Mines. Pointing out that the company is now producing the metal at a faster rate than it can sell it, he said it was its policy to prevent any abrupt price rises by building up sufficient stocks to provide for any unexpected increases in future demand. He did not, however, suggest any likelihood of a sharp increase in demand in the near future. On the other hand, he did see fit to draw attention to Russia's plans to increase her chemical and petroleum outputs, which could easily lead to an increase in her domestic platinum consumption. This, in turn, might lead to fewer Russian offerings on the world market, but other factors affecting Russian production and consumption of platinum are so uncertain—for one thing, very little is known of her actual output from year to year—that it is really impossible to do more than guess the future pattern.

Iridium.—The iridium market in January was again quite featureless and the price of sponge and powder remains at a nominal £24 to £26 15s. per troy oz.

Palladium.—Palladium has shown a little more strength in the market since the New Year than was thought likely towards the end of 1959 and the price per troy oz. has advanced to £9 7s. 6d., against £8 12s. 6d. previously.

Osmium.—The price throughout January remained at £23 to £32 5s. a troy oz.

Tellurium.—Tellurium prices have been advanced since the New Year as demand for the metal for use in copper alloys and in the rubber industry has increased. Lump and powder 99% to 99·5% is now quoted at 21s. 6d. to 25s. a lb. The price of tellurium sticks has advanced by 10s. a lb., to 30s.

Tungsten.—Tungsten ore prices hardened at the beginning of the month, although the volume of business declined. British Tungsten, the Government agents, again decided to limit their sales for the month to 80 tons, but with this quantity soon disposed of they made available further small parcels at a premium of 2s. 6d. Trading in the open market increased later in the month, but demand

was almost exclusively from U.K. consumers. With no lack of supplies prices steadied after reaching 155s. to 160s. a unit c.i.f. on January 18 and remained at that level for the rest of the month, while U.K. and European inquiry tailed off somewhat and business with U.S. consumers increased.

Nickel.—Nickel is once more quoted at £600 a ton, delivered. At about the middle of the month the United States Government announced through the General Services Administration that it has decided to sell 9,500 short tons of nickel cathodes from the supplemental stockpile in lots varying from 10 tons to 500 tons. Altogether, however, the G.S.A. will be releasing 17,500 tons of nickel in the none-too-distant future, for it has also to withdraw a further 8,000 tons of nickel cathodes from the supplemental stockpile to use instead of Nicaro sinter to "pay" International Nickel under the terms of an agreement made in August, 1959, whereby it will be relieved of its existing obligation to purchase premium price stockpile nickel from that company. Further details were given in the report in the September issue.

Chrome Ore.—The chrome-ore market has at last shown signs of an improvement. Stainless-steel production in Europe and particularly in the U.K. is now booming and with it demand for ferro-chrome (and hence for chrome ore). Japanese ferro-chrome producers, too, have been seeking further supplies of chrome ore and are reported to have bought some Soviet-produced material at c.i.f. prices about $5 a ton below those currently asked for Indian and South African ore. If this proves satisfactory it is quite possible that further contracts will ensue. At present quotations for Rhodesian metallurgical and Turkish ore are again £15 15s. a ton c.i.f. and a nominal $35.50 f.o.b. respectively.

Turkish producers had the opportunity in January to offer material to the U.S. Commodity Credit Corporation in exchange for 80,000 tons of surplus American wheat. At the same time they went on record as having asked their Government for special monetary and tax favours which, if granted, will enable them to come up with some reasonably priced offers of material.

Molybdenite.—There were no new features as regards the market for molybdenum ore last month and quotations for American Metal Climax ore remained at 8s. 11d. a lb. of Mo contained, f.o.b. mine. Material from other sources was again quoted at 9s. 3½d. a lb. c.i.f.

Manganese Ore.—The barter deal for Indian ore against surplus U.S. wheat, which has been under negotiation for the past three years, reached a form of conclusion in January with the U.S. stating its willingness to accept 170,000 tons of Indian ore and 100,000 tons of ferro-manganese by June 1 of this year. The Indian authorities, however, are reported to be doubtful about their ability to supply these quantities in the time and have already asked for an extension. Indian asking prices have risen on sentiment following the news, but this has had little effect on the rest of the market in view of the stocks known to be held in India. The general position is still rather unsatisfactory. The price for 46% to 48% ore c.i.f. Europe is still a nominal 68d. to 73d.

Tin, Copper, Lead, and Zinc Prices

Tin, minimum, 99·75%; Copper, electro; Lead, minimum 99·75%; and Zinc, minimum 98%, per ton.

Date	Tin		Copper		Lead		Zinc	
	Settlement	3 Months	Spot	3 Months	Spot	3 Months	Spot	3 Months
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Jan. 11	789 0	786 15	253 17½	244 17½	75 12½	74 17½	95 7½	91 5
12	790 0	786 15	257 0	246 5	75 11¼	75 3¾	95 13¾	92 7½
13	790 0	786 15	255 15	245 5	75 1¼	74 16½	94 17½	91 12½
14	791 0	787 15	256 0	245 5	74 17½	74 16¼	94 17½	92 2½
15	791 0	787 15	258 17½	246 17½	75 1¼	74 16¼	95 11¼	92 6¼
18	793 10	789 15	260 5	247 15	75 1¼	74 18¾	95 8¾	92 11¼
19	794 0	789 5	256 15	245 17½	74 13¾	74 16¼	94 5	91 17½
20	796 0	790 5	259 5	246 7½	74 16½	74 13¾	93 13¾	91 17½
21	793 0	790 5	260 15	246 15	74 6¼	74 6¼	93 17½	92 2½
22	792 0	789 0	261 10	247 17½	73 18¾	74 1¼	93 17½	92 12½
25	790 0	787 5	264 5	248 17½	73 17½	74 1¼	93 7½	92 7½
26	793 0	789 0	268 10	251 5	74 3¾	74 8¾	93 3¾	92 6¼
27	793 10	788 5	271 10	253 17½	74 13¾	74 17½	93 6¼	92 11½
28	794 10	788 5	272 10	254 15	75 1¼	75 3¼	93 17½	92 18¾
29	793 10	788 10	262 0	247 15	74 16¼	74 18¾	93 12½	92 17½
Feb. 1	794 0	788 15	266 17½	249 2½	74 13¾	75 13¾	92 12½	91 12½
2	793 0	788 15	255 15	243 15	73 8¾	73 15	90 7½	89 12½
3	793 0	788 5	259 0	244 15	73 13¾	73 13¾	90 2½	89 12½
4	793 0	788 15	263 17½	244 15	73 15	73 17½	89 16½	89 16½
5	793 0	789 5	271 15	248 12½	72 8¾	72 16¼	89 12½	89 12½
8	792 0	788 15	269 0	244 15	72 7½	72 11¼	89 11¼	89 16½
9	793 0	789 0	276 15	249 7½	71 17½	72 5	89 13¾	89 17½
10	793 0	789 10	274 10	247 15	71 18¾	72 6¼	89 16¼	89 18¾

Statistics

TRANSVAAL AND O.F.S. GOLD OUTPUTS

	Dec.		Jan.	
	Treated Tons	Yield Oz.*	Treated Tons	Yield Oz.†
Blyvooruitzicht	123,000	80,867	128,000	83,825
Brakpan	143,000	17,292	142,300	17,268
Buffelsfontein‡	145,000	56,350	145,000	56,944
City Deep	97,000	20,418	109,000	22,897
Cons. Main Reef	75,000	15,480	82,000	15,458
Crown Mines	207,000	34,113	213,000	34,830
Daggafontein	219,000	44,467	230,000	46,351
Doornfontein‡	93,000	38,032	96,000	38,890
D'rb'n Roodeport Deep	186,000	34,361	196,000	35,580
East Champ D'Or‡	12,000	303	12,000	306
East Daggafontein	100,000	16,959	102,000	17,200
East Geduld	132,000	37,257	134,000	39,671
East Rand P.M.	203,000	54,201	218,000	55,479
Eastern Transvaal Consol	18,800	6,193	18,700	6,189
Ellaton‡	29,000	6,792	29,000	6,890
Freddies Consol.	54,000	13,015	59,000	13,279
Free State Geduld	93,500	80,647	95,000	81,941
Geduld	72,000	13,513	72,000	13,949
Government G.M. Areas‡	51,000	10,617	54,000	10,856
Grootvlei Proprietary	210,000	43,890	215,000	44,982
Harmony Gold Mining	141,000	56,478	150,000	60,163
Hartebeestfontein‡	101,000	48,480	100,000	47,000
Libanon	110,000	25,739	112,000	26,301
Loraine	77,500	15,888	75,000	15,563
Luipaards Vlei‡	118,000	13,496	117,000	13,102
Marievale Consolidated	94,000	22,741	99,000	24,181
Merriespruit‡	—	—	—	—
Modderfontein East‡	122,000	12,782	131,000	12,983
New Kleinfontein	80,000	9,878	83,000	10,123
New Klerksdorp‡	10,200	1,234	11,000	1,277
President Brand	115,000	94,642	115,000	94,180
President Steyn	99,000	39,193	102,000	40,166
Rand Leases	163,000	24,857	175,000	26,512
Randfontein‡	189,000	13,461	183,000	12,996
Rietfontein Consolid't'd.	16,000	4,247	16,000	4,245
Robinson Deep	50,000	9,000	50,000	9,637
Rose Deep	25,000	4,504	27,000	4,464
St. Helena Gold Mines	150,000	49,120	155,000	51,150
Simmer and Jack	73,000	13,704	77,000	13,840
S. African Land and Ex.	90,000	18,764	93,000	19,390
S. Roodepoort M.R.	30,000	7,235	30,000	7,233
Spaarwater Gold	10,600	3,339	10,900	3,395
Springs	101,000	13,891	105,000	14,414
Stilfontein Gold Mining‡	160,000	72,037	160,000	72,080
Sub Nigel	64,000	15,088	66,500	15,265
Transvaal G.M. Estates	8,200	1,878	7,600	2,030
Vaal Reefs‡	93,000	41,850	94,000	42,300
Van Dyk Consolidated	69,000	12,537	69,000	12,035
Venterspost Gold	121,000	31,194	129,000	32,582
Village Main Reef	29,500	4,350	30,500	4,666
Virginia O.F.S.‡	132,000	29,832	133,000	30,058
Vlakfontein	49,500	17,913	51,000	18,220
Vogelstruisbult‡	87,000	18,732	88,000	18,930
Welkom Gold Mining	95,000	30,220	98,000	30,445
West Driefontein‡	110,000	100,657	115,000	105,241
West Rand Consol.‡	200,000	19,392	203,000	19,826
Western Holdings	140,000	93,128	147,000	97,755
Western Reefs	134,000	36,516	134,500	37,660
Winkelhaak	79,000	22,917	80,000	24,401
Witwatersrand Nigel	18,300	4,272	19,000	4,395

† 250s. 4d. * 249s. 11d. ‡ Gold and Uranium.

COST AND PROFIT IN THE UNION

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Dec., 1958	16,540,150	67 7	47 10	19 9	25,934,441
Jan., 1959	—	—	—	—	—
Feb.	—	—	—	—	—
Mar.	16,743,500	68 0	45 4	22 8	25,934,881
April	—	—	—	—	—
May	—	—	—	—	—
June	17,845,100	69 1	45 2	23 11	28,473,191
July	—	—	—	—	—
August	—	—	—	—	—
Sept.	18,214,200	70 5	45 2	25 2	30,140,529
Oct.	—	—	—	—	—
Nov.	—	—	—	—	—
Dec.	—	—	—	—	30,559,937

* 3 Months.

PRODUCTION OF GOLD IN SOUTH AFRICA

	Rand and O.F.S.	Outside	Total
	Oz.	Oz.	Oz.
January, 1959	1,506,670	39,515	1,546,187
February	1,472,090	34,618	1,506,708
March	1,561,196	32,271	1,593,467
April	1,616,891	36,815	1,653,706
May	1,641,990	30,371	1,672,361
June	1,665,503	34,465	1,699,968
July	1,700,968	48,414	1,749,382
August	1,699,098	36,052	1,735,150
September	1,701,485	36,567	1,738,052
October	1,718,916	33,576	1,752,492
November	1,688,379	34,903	1,723,282
December	1,662,043	31,309	1,693,352

NATIVES EMPLOYED IN THE SOUTH AFRICAN MINES

	Gold Mines	Coal Mines	Total
April 30, 1959	383,710	33,081	416,791
May 31	385,278	33,186	418,464
June 30	383,903	33,146	417,049
July 31	381,190	33,295	414,485
August 31	377,257	32,994	410,251
September 30	371,813	32,903	404,716
October 31	365,833	32,567	398,400
November 30	358,746	32,067	390,813
December 31	354,058	31,963	386,021

MISCELLANEOUS METAL OUTPUTS

	4-Week Period To Dec. 31.		
	Tons Ore	Lead Concs. tons	Zinc Concs. tons
Broken Hill South	29,200	4,281	4,807
Electrolytic Zinc	15,582	647	4,278
Lake George	—	—	—
Mount Isa Mines**	—	—	—
New Broken Hill	54,403	3,600†	2,766
North Broken Hill	32,713	6,055	6,268
Zinc Corp.	—	—	—
Rhodesia Broken Hill*	—	3,600†	7,670†

* 3 Mths. ** Copper 2,615 tons. † Metal.

RHODESIAN GOLD OUTPUTS

	December		January	
	Tons	Oz.	Tons	Oz.
Cam and Motor	32,746	—	32,775	—
Falcon Mines	20,500	3,900	20,500	3,904
Globe and Phœnix	—	—	5,900	3,208
Motapa Gold Mining	—	—	—	—
Mazoe	2,911	—	3,274	—
Coronation Syndicate	12,346	—	12,313	—
Phœnix Prince*	—	—	—	—

* 3 Months.

WEST AFRICAN GOLD OUTPUTS

	December		January	
	Tons	Oz.	Tons	Oz.
Amalgamated Banket	60,300	13,928	62,351	12,604
Ariston Gold Mines	40,680	13,047	40,190	13,032
Ashanti Goldfields	36,500	30,550	35,500	29,050
Bibiani	30,000	7,000	30,000	7,000
Bremang	—	5,639	—	—
Ghana Main Reef	12,203	4,254	12,077	4,307
Konongo	6,810	3,706	6,810	3,498
Lyndhurst	—	—	—	—

PRODUCTION OF GOLD AND SILVER IN RHODESIA

	1958		1959	
	Gold (oz.)	Silver (oz.)	Gold (oz.)	Silver (oz.)
January	44,305	46,553	46,489	18,077
February	43,591	21,313	43,366	19,806
March	43,830	8,179	48,397	17,394
April	46,587	22,573	—	—
May	46,015	19,937	46,423	46,280
June	46,453	20,105	49,995	31,386
July	44,244	19,170	46,512	32,734
August	47,484	20,549	38,727	29,178
September	48,295	21,141	56,760	33,837
October	46,311	6,342	48,528	32,314
November	47,994	16,435	—	—
December	48,888	30,724	—	—

WESTRALIAN GOLD PRODUCTION

	1957	1958	1959
	Oz.	Oz.	Oz.
January	106,722	66,562	63,924
February	64,949	65,965	65,035
March	67,121	65,420	65,408
April	66,435	60,855	62,686
May	64,886	64,196	64,184
June	65,142	67,929	74,590
July	74,420	81,106	78,974
August	75,727	68,610	—
September	64,422	68,744	—
October	64,524	70,128	70,427
November	65,700	67,562	68,858
December	66,562	120,106	117,474
Total	846,610	867,187	866,060

AUSTRALIAN GOLD OUTPUTS

	4-Week Period			
	To Dec. 8		To Jan. 5	
	Tons	Oz.	Tons	Oz.
Central Norseman	14,074	7,052	14,262	7,118
Gold Mines of Kalgoorlie	41,303	12,038	41,152	11,440
Gt. Boulder Gold Mines*	—	—	—	—
Gt. Western Consolidated	34,415	4,917	31,611	5,447
Lake View and Star*	178,303	40,778	—	—
North Kalgurli	27,677	7,164	—	—
Sons of Gwalia	12,440	2,704	15,718	3,327
Mount Morgan	—	8,951	—	6,550

* 3 Months

ONTARIO GOLD AND SILVER OUTPUT

	Tons Milled	Gold Oz.	Silver Oz.	Value Canad'n $
August, 1958	740,459	218,126	38,940	7,355,406
September	771,115	202,708	31,543	7,006,517
October	801,965	200,006	34,914	7,178,218
November	783,065	230,251	35,097	7,842,435
December	787,573	219,351	30,980	7,490,004
January, 1959	799,178	227,656	41,277	7,700,672
February	727,843	227,981	32,976	7,708,523
March	807,952	223,728	33,045	7,616,425
April	776,583	225,027	32,778	7,712,425
May	791,199	227,924	34,006	7,713,970
June	768,725	213,486	31,692	7,178,823
July	774,749	221,814	32,172	7,498,030
August	683,819	191,598	29,141	6,428,545
September	754,208	213,772	34,139	7,116,556
October	794,030	227,192	34,733	7,558,567
November	770,437	227,176	35,262	7,600,949

MISCELLANEOUS GOLD AND SILVER OUTPUTS

	Dec.		Jan.	
	Tons	Oz.	Tons.	Oz.
Clutha River	—	—	—	312
Lampa (Peru)†	—	34,104	—	—
New Guinea Goldfields	4,137	1,666	—	—
Yukon Consol.	—	—	—	—

† Oz. Silver : Copper, 100½ : 95½ tons.

AUSTRALIAN BASE-METAL OUTPUTS

Period	Concentrate Production (Long Tons)		
	Zinc	Copper (*a*)	Lead
1958	263,044	75,047	327,368
Provisional			
1959—January	11,966	7,372	17,350
February	22,657	6,873	29,650
March	18,054	7,856	23,318
April	22,492	8,007	28,785
May	20,091	7,269	28,416
June	20,323	8,596	25,569
July	24,370	7,013	31,654
August	20,803	7,741	25,438
September	22,047	7,800	25,592
October	19,878	8,853	23,892
November	25,307	7,816	32,131

(*a*) includes Cu content of direct smelting ore.

OUTPUTS OF MALAYAN TIN COMPANIES IN LONG TONS OF CONCENTRATES

	Nov.	Dec.	Jan.
Ampat Tin	52½	52	81
Austral Amalgamated	—	—	—
Ayer Hitam	—	353*	—
Batu Selangor	—	—	—
Berjuntai	199	167	182
Chenderiang	—	47½*	—
Gopeng Consolidated	—	279*	—
Hongkong Tin	—	65*	—
Idris Hydraulic	—	41*	—
Ipoh	—	68*	—
Jelapang Tin	—	—	—
Kampong Lanjut	94	98	84
Kamunting	100	102	115
Kent (F.M.S.)	—	50*	—
Kepong	—	—	—
Killinghall	—	80*	—
Kinta Kellas	21½	—	31
Kinta Tin Mines	—	—	—
Klang River	—	—	—
Kramat	62	78	76½
Kuala Kampar	94	68	64
Kuala Lumpur	—	—	—
Kuchai	—	—	—
Lahat Mines	—	—	—
Larut	—	—	—
Lower Perak	87	142½	166
Malayan	—	741½*	—
Malaysiam	5	—	—
Pacific Tin Consolidated	—	—	—
Pahang Consolidated	—	465½*	—
Pengkalen	—	85*	—
Petaling Tin	—	308*	—
Puket	—	—	—
Rahman Hydraulic	—	—	—
Rambutan	—	29½*	—
Rantau	45	57	39½
Rawang Concessions	—	—	—
Rawang Tin Fields	—	—	—
Renong	—	228½*	—
Selayang	—	46*	—
Siamese Tin Syndicate (Malaya)	32	—	25
Southern Kinta	262	298	268
Southern Malayan	—	598½*	—
Southern Tronoh	—	—	—
Sungei Besi	—	219*	—
Sungei Kinta	—	50*	—
Sungei Way	—	—	—
Taiping Consolidated	—	266*	—
Tambah	—	—	—
Tanjong	—	176*	—
Tekka	—	24½*	—
Tekka-Taiping	—	—	—
Temoh	—	9*	—
Tongkah Compound	—	—	—
Tongkah Harbour	48	44½	33½
Tronoh	—	650*	—
Ulu Klang	—	—	—

* 3 Months.

MISCELLANEOUS TIN COMPANIES' OUTPUTS IN LONG TONS OF CONCENTRATES

	Dec.		Jan.	
	Tin	Columbite	Tin	Columbite
Amalgamated Tin Mines	276	39	—	—
Anglo-Burma Tin *	19	—	—	—
Bangrin	37	—	30	—
Beralt	6	157†	5	160†
Bisichi	40	37½	—	—
Ex-Lands Nigeria	38	—	50	—
Geevor	60	—	60	—
Gold and Base Metal	65	7	—	—
Jantar Nigeria	14½	17	—	—
Jos Tin	11	—	—	—
Kaduna Prospectors	5	—	6	—
Kaduna Syndicate	22½	—	30	—
Katu Tin	25	—	27	—
Keffi Tin	—	—	—	—
London Nigerian Mines	—	—	—	—
Mawchi Mines	—	—	—	—
Naraguta Extended	15	—	12	—
Naraguta Karama	10½	—	9½	—
Naraguta Tin	—	—	—	—
Renong Consolidated	—	—	—	—
Ribon Valley (Nigeria)	—	—	18½	1
Siamese Tin Syndicate	83	—	52	—
South Bukeru	—	—	—	—
South Crofty	74	—	78	—
Tavoy Tin	—	—	—	—
Tin Fields of Nigeria	—	—	—	—
United Tin Areas of Nigeria	—	—	—	—

* 3 months. † Wolfram.

SOUTH AFRICAN MINERAL OUTPUT

November, 1959.

Gold	1,721,819 oz.
Silver	177,582 oz.
Diamonds	102,601 carats.*
Coal	3,211,413 tons.
Copper	(*a*) — tons in matte and copper-gold concentrates. (*b*) 5,041 tons of 99·29%.
Tin	tons concs.
Platinum (concentrates, etc.)	—
Platinum (crude)	—
Asbestos	15,155 tons.
Chrome Ore	60,398 tons.
Manganese Ore	95,156 tons.
Lead Concs.	20 tons.

* *October, 1959*

IMPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM

		Nov.	Dec.
Iron Ore	tons	1,363,488	1,289,504
Manganese Ore	„	15,692	25,553
Iron and Steel	„	74,003	74,321
Iron Pyrites	„	4,075	7,935
Copper Metal	„	33,957	35,139
Tin Ore	„	6,782	6,036
Tin Metal	„	45	503
Lead	„	7,551	18,486
Zinc Ore and Conc.	„	15,547	13,266
Zinc	„	14,707	16,205
Tungsten Ores	„	536	799
Chrome Ore	„	18,302	8,336
Bauxite	„	37,756	17,562
Antimony Ore and Concs.	„	1,257	1,220
Titanium Ore	„	18,414	5,463
Nickel Ore	„	—	—
Tantalite/Columbite	„	52	66
Sulphur	„	20,560	41,382
Barytes	„	2,938	2,955
Asbestos	„	11,900	13,357
Magnesite	„	1,317	2,982
Mica	„	723	358
Graphite	„	700	535
Mineral Phosphates	„	75,849	62,016
Molybdenum Ore	„	422	544
Nickel	cwt.	132,028	84,614
Aluminium	„	467,737	552,234
Mercury	lb.	146,727	156,015
Bismuth	„	70,846	43,183
Cadmium	„	198,896	267,879
Cobalt and Cobalt Alloys	„	15,305	229,560
Selenium	„	26,197	20,621
Petroleum Motor Spirit	1,000 gals.	77,365	70,664
Crude	„	843,597	879,875

Prices of Chemicals

The figures given below represent the latest available.

		£	s.	d.
Acetic Acid, Glacial	per ton	106	0	0
„ „ 80% Technical	„	97	0	0
Alum, Comml.	„	25	0	0
Aluminium Sulphate	„	16	10	0
Ammonia, Anhydrous	per lb.		2	0
Ammonium Carbonate	per ton	59	0	0
„ Chloride, 98%	„	26	0	0
„ Phosphate (Mono- and Di-)	„	102	0	0
Antimony Sulphide, golden	per lb.		3	0
Arsenic, White, 99/100%	per ton	47	10	0
Barium Carbonate (native), 94%	„	Nominal		
„ Chloride	„	53	0	0
Barytes (Bleached)	„	20	0	0
Benzene	per gal.		5	2
Bleaching Powder, 35% Cl.	per ton	30	7	6
Borax	„	46	0	0
Boric Acid, Comml.	„	77	0	0
Calcium Carbide	„	40	17	9
„ Chloride, solid, 70/75%	„	13	5	0
Carbolic Acid, crystals	per lb.		1	6
Carbon Bisulphide	per ton	62	10	0
Chromic Acid (ton lots)	per lb.		2	2½
Citric Acid	per cwt.	9	15	0
Copper Sulphate	per ton	78	15	0
Creosote Oil (f.o.r. in Bulk)	per gal.		1	2
Cresylic Acid, refined	„		7	0
Hydrochloric Acid 28° Tw.	per carboy		13	0
Hydrofluoric Acid, 59/60%	per lb.		1	1
Iron Sulphate	per ton	3	17	6
Lead, Carbonate, white	„	117	10	0
„ Nitrate	„	116	15	0
„ Oxide, Litharge	„	107	15	0
„ Red	„	105	15	0
Lime Acetate, brown	„	40	0	0
Lithopone	„	56	10	0
Magnesite, Calcined	„	20	0	0
„ Raw	„	9	0	0
Magnesium Chloride, ex Wharf	„	16	0	0
„ Sulphate, Comml.	„	15	10	0
Methylated Spirit, Industrial, 66 O.P.	per gal.		6	3
Nitric Acid, 80° Tw.	per ton	37	10	0
Oxalic Acid	„	129	0	0
Phosphoric Acid (S.G. 1·750)	per lb.		1	4
Pine Oil	per ton	Nominal		
Potassium Bichromate	per lb.		1	2½
„ Carbonate (hydrated)	per ton	74	10	0
„ Chloride	„	21	0	0
„ Iodide	per lb.		6	10
„ Amyl Xanthate	„	Nominal		
„ Ethyl Xanthate	„	Nominal		
„ Hydrate (Caustic) flake	per ton	118	0	0
„ Nitrate	per cwt.	4	1	0
„ Permanganate	per ton	198	0	0
„ Sulphate, 50%	„	20	13	0
Sodium Acetate	„	75	10	0
„ Arsenate, 58–60%	„	Nominal		
„ Bicarbonate	„	18	10	0
„ Bichromate	per lb.		1	0
„ Carbonate (crystals)	per ton	Nominal		
„ „ (Soda Ash) 58%	„	13	15	0
„ Chlorate	„	91	0	0
„ Cyanide 100% NcAN basis	per cwt.	6	6	6
„ Hydrate, 76/77%, solid	per ton	33	0	0
„ Hyposulphite, Comml.	„	2	15	0
„ Nitrate, Comml.	„	29	0	0
„ Phosphate (Dibasic)	„	40	10	0
„ Prussiate	per lb.		1	0½
„ Silicate	per ton	11	10	0
„ Sulphate (Glauber's Salt)	„	9	15	0
„ „ (Salt-Cake)	„	10	0	0
„ Sulphide, flakes, 60/62%	„	38	12	6
„ Sulphite, Comml.	„	27	15	0
Sulphur, American, Rock (Truckload)	„	14	0	0
„ Ground, Crude	„	17	10	0
Sulphuric Acid, 168° Tw.	„	12	0	0
„ „ free from Arsenic, 140° Tw.	„	7	0	0
Superphosphate of Lime, 18% P_2O_5	„	14	18	6
Tin Oxide	„	Nominal		
Titanium Oxide, Rutile	„	172	0	0
„ White, 25%	„	85	0	0
Zinc Chloride	„	95	0	0
„ Dust, 95/97% (4-ton lots)	„	126	0	0
„ Oxide	„	110	0	0
„ Sulphate	„	32	0	0

Share Quotations

Shares of £1 par value except where otherwise stated.

GOLD AND SILVER:	Jan. 8, 1960 £ s. d.	Feb. 9, 1960 £ s. d.
SOUTH AFRICA:		
Blinkpoort (5s.)	4 13 9	4 8 9
Blyvooruitzicht (2s. 6d.)	1 9 6	1 9 3
Brakpan (3d.)	5 3	5 0
Buffelsfontein (10s.)	2 10 6	2 10 0
City Deep	1 1 6	19 6
Consolidated Main Reef	18 9	17 6
Crown Mines (10s.)	1 8 6	1 6 3
Daggafontein (5s.)	1 5 3	1 2 9
Dominion Reefs (5s.)	12 6	12 6
Doornfontein (10s.)	1 14 0	1 14 3
Durban Roodepoort Deep (10s.)	2 0 6	1 15 6
East Champ d'Or (2s. 6d.)	2 3	2 0
East Daggafontein (10s.)	10 0	8 9
East Geduld (4s.)	1 5 0	1 3 6
East Rand Ext. (5s.)	1 7 0	1 8 0
East Rand Proprietary (10s.)	2 3 3	2 1 0
Freddies Consol.	2 9	2 3
Free State Dev. (5s.)	8 9	8 0
Free State Geduld (5s.)	9 9 0	8 18 9
Free State Saaiplaas (10s.)	1 0 3	18 9
Geduld	3 17 6	3 13 9
Government Gold Mining Areas (3d.)	3 6	3 3
Grootvlei (5s.)	1 4 3	1 1 0
Harmony (5s.)	1 19 3	1 17 3
Hartebeestfontein (10s.)	2 18 0	2 18 6
Libanon (10s.)	16 9	16 3
Loraine (10s.)	1 17 6	1 15 3
Luipaards Vlei (2s.)	18 3	8 3
Marievale (10s.)	1 9 3	1 17 0
Merriespruit (5s.)	2 6	2 3
Modderfontein B (3d.)	2 3	2 0
Modderfontein East	16 3	15 9
New Kleinfontein	5 6	4 6
New Pioneer (5s.)	1 19 3	1 18 0
New State Areas (15s. 6d.)	1 3	1 3
President Brand (5s.)	3 18 6	3 15 3
President Steyn (5s.)	1 10 3	1 7 9
Rand Leases (9s. 3d.)	7 6	6 9
Randfontein	19 9	19 6
Rietfontein (3s.)	4 6	4 6
Robinson Deep (5s. 6d.)	6 3	6 0
Rose Deep (3s. 6d.)	9 6	9 6
St. Helena (10s.)	3 18 0	4 2 0
Simmer and Jack (1s. 6d.)	2 0	1 6
South African Land (3s. 6d.)	15 9	15 9
Springs (5d.)	1 9	1 9
Stilfontein (5s.)	2 1 3	2 0 0
Sub Nigel (3d.)	11 9	10 9
Vaal Reefs (5s.)	2 8 9	2 11 6
Van Dyk (3d.)	4 3	4 0
Venterspost (10s.)	1 2 9	1 2 6
Virginia (5s.)	5 3	5 3
Vlakfontein (10s.)	19 9	18 9
Vogelstruisbult (3d.)	6 9	6 6
Welkom (5s.)	1 3 6	1 0 9
West Driefontein (10s.)	10 2 6	9 12 6
West Rand Consolidated (10s.)	1 1 9	19 9
West Witwatersrand Areas (2s. 6d.)	4 6 9	4 0 0
Western Holdings (5s.)	9 1 9	8 15 0
Western Reefs (5s.)	1 11 3	1 12 0
Winkelhaak (10s.)	1 6 6	1 5 3
Witwatersrand Nigel (2s. 6d.)	1 6	1 3
Zandpan (10s.)	18 6	1 0 3
RHODESIA:		
Cam and Motor (2s. 6d.)	10 6	—
Chicago-Gaika (10s.)	1 5 0	1 5 0
Coronation (2s. 6d.)	6 6	6 0
Falcon (5s.)	12 0	11 9
Globe and Phœnix (5s.)	2 1 3	1 17 0
Motapa (5s.)	9	0 9
GOLD COAST:		
Amalgamated Banket (3s.)	1 9	1 6
Ariston Gold (2s. 6d.)	5 3	5 0
Ashanti Goldfields (4s.)	1 4 6	1 3 6
Bibiani (4s.)	4 3	3 9
Bremang Gold Dredging (5s.)	3 6	3 6
Ghana Main Reef (5s.)	3 9	3 6
Konongo (2s.)	1 9	2 0
Kwahu (2s.)	6 9	6 9
Offin River (2s. 6d.)	3 9	3 9
Western Selection (5s.)	6 0	6 3
AUSTRALASIA:		
Gold Fields Aust. Dev. (3s.), W.A.	1 6	1 9
Gold Mines of Kalgoorlie (10s.)	8 3	8 0
Great Boulder Propriet'y (2s.), W.A.	12 3	11 9
Lake View and Star (4s.), W.A.	1 9 0	1 6 6
Mount Morgan (10s.), Q.	18 6	18 6
New Guinea Gold (4s. 3d.)	1 9	1 9
North Kalgurli (1912) (2s.), W.A.	10 0	10 0
Sons of Gwalia (10s.), W.A.	2 9	2 9
Western Mining (5s.), W.A.	10 0	10 0

	Jan. 8, 1960 £ s. d.	Feb. 9, 1960 £ s. d.
MISCELLANEOUS:		
Fresnillo ($1·00)	1 11 3	1 12 6
Kentan Gold Areas	1 18 9	1 18 0
St. John d'el Rey, Brazil	3 15 0	4 7 6
Yukon Consolidated ($1)	8 3	5 0
COPPER:		
Bancroft Mines (5s.), N. Rhodesia	1 7 6	1 6 9
Esperanza (2s. 6d.), Cyprus	2 10	2 6
Indian (2s.)	4 9	4 9
MTD (Mangula) (5s.)	12 9	12 3
Messina (5s.), Transvaal	7 3 9	6 17 0
Mount Lyell, (5s.) Tasmania	—	6 6
Nchanga Consolidated, N. Rhodesia	3 15 9	3 8 6
Rhokana Corporation, N. Rhodesia	3 4 6	3 6 9
Roan Antelope (5s.), N. Rhodesia	8 6	8 6
Tanganyika Concessions (10s.)	2 7 6	2 4 6
LEAD-ZINC:		
Broken Hill South (1s.), N.S.W.	12 9	13 9
Burma Mines (3s. 6d.)	2 0	1 9
Consol. Zinc Corp. Ord.	3 15 6	3 15 6
Lake George (5s.), N.S.W.	4 3	3 9
Mount Isa, Queensland (5s. Aust.)	2 15 0	2 15 9
New Broken Hill (5s.), N.S.W.	2 1 0	2 1 6
North Broken Hill (5s.), N.S.W.	5 12 6	6 10 0
Rhodesia Broken Hill (5s.)	12 0	11 6
San Francisco (10s.), Mexico	1 0 9	1 0 6
TIN:		
Amalgamated Tin (5s.), Nigeria	9 9	10 6
Ampat (4s.), Malaya	12 6	12 6
Ayer Hitam (5s.), Malaya	2 19 0	2 19 0
Beralt (5s.), Portugal	1 14 0	1 11 0
Bisichi (2s. 6d.), Nigeria	5 9	5 9
Ex-Lands (2s.), Nigeria	2 9	2 9
Geevor (5s.), Cornwall	1 1 3	1 2 3
Gold Base Metals (2s. 6d.), Nigeria	2 0	2 0
Hongkong (5s.), Malaya	5 9	6 3
Jantar Nigeria (3s.)	4 6	4 9
Kaduna Syndicate (2s.), Nigeria	2 6	2 6
Kamunting (5s.), Malaya	15 9	15 9
Malayan Tin Dredging (5s.)	18 9	1 1 3
Mawchi Mines (4s.), Burma	1 9	1 9
Naraguta Extended (5s.), Nigeria	1 2	1 9
Pahang (5s.), Malaya	9 3	9 3
Ribon Valley (2s.), Nigeria	1 0	10½
Siamese Synd. (5s.)	10 6	12 3
South Crofty (5s.), Cornwall	6 3	6 3
Southern Kinta (5s.), Malaya	1 10 9	1 8 6
Southern Malayan (5s.)	18 6	18 3
Southern Tronoh (5s.), Malaya	13 6	14 0
Sungei Besi (4s.), Malaya	1 1 3	1 0 6
Sungei Kinta, Malaya	17 0	17 6
Tekka (12s. 6d.), Malaya	6 9	6 6
Tronoh (5s.), Malaya	1 10 3	1 9 6
DIAMONDS:		
Anglo American Investment	16 12 6	17 0 0
Consol African Selection Trust (5s.)	1 6 0	1 6 9
Consolidated of S.W.A. Pref. (10s.)	11 3	11 3
De Beers Deferred (5s.)	9 13 0	9 16 3
FINANCE, Etc.		
African & European (10s.)	4 6 9	4 5 6
Anglo American Corporation (10s.)	10 17 3	11 8 3
Anglo Transvaal 'A' (5s.)	2 11 0	2 11 3
British South Africa (15s.)	5 13 9	5 8 9
British Tin Investment (10s.)	1 7 3	1 8 6
Broken Hill Proprietary	3 0 6	3 4 0
Camp Bird (10s.)	11 0	11 9
Central Mining	4 16 3	4 11 6
Central Provinces Manganese (10s.)	1 12 6	1 15 0
Consolidated Gold Fields	4 19 6	4 12 6
Consolidated Mines Selection (10s.)	2 10 9	2 8 9
Corner House	1 2 9	1 2 3
East Rand Consolidated (5s.)	2 9	2 6
Free State Development (5s.)	8 9	8 0
General Exploration O.F.S. (2s. 6d.)	6 6	5 6
General Mining and Finance	7 3 3	7 0 0
Hendersons (4s.)	15 0	14 0
Johannesburg Consolidated	4 0 0	3 15 0
London & Rhod. M. & L. (5s.)	8 9	8 3
London Tin Corporation (4s.)	11 0	11 3
Lydenburg Est. (5s.)	18 3	17 6
Marsman Investments (10s.)	2 9	2 6
National Mining	3 0	2 9
Rand Mines (5s.)	5 3 9	5 3 6
Rand Selection (5s.)	3 7 6	3 11 9
Rhodesian Anglo American (10s.)	4 1 3	4 7 6
Rhodesian Corporation (5s.)	3 9	3 9
Rhodesian Selection Trust (5s.)	15 9	15 9
Rio Tinto (10s.)	2 8 6	2 3 9
Selection Trust (10s.)	6 3 9	6 0 9
South West Africa Co. (3s. 4d.)	18 9	18 9
Union Corporation (2s. 6d.)	4 6 0	4 4 0
Vereeniging	6 17 4	7 0 0
West Rand Inv. Trust (10s.)	3 15 0	3 8 0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section abstracts of important articles and papers appearing in technical journals and proceedings of societies are given, together with brief records of other articles and papers; also notices of new books and pamphlets and lists of patents on mining and metallurgical subjects.

Kerosine Flotation of Coal

Semi-commercial studies in cell performance during the kerosine flotation of coal are outlined by J. B. Gayle and others in Report of Investigations 5528 of the United States Bureau of Mines. The authors say that problems relating to the flotation of coal differ somewhat from those with most minerals in that finely-divided particles of coal are inherently floatable whereas those of the associated impurities are not. Moreover, they go on, the present economic situation with regard to coal is such that the cost of beneficiation must be kept to a minimum and efficiency of operation is thus of paramount importance. For these reasons a study of factors influencing coal-flotation rates and recoveries is being conducted at the Bureau of Mines Coal Laboratory, the first report presenting results indicating that marked increases in kerosine flotation rates for coal can be achieved by using impeller restrictions. The further work now described presents additional data regarding this variable and also includes results indicating that similar increases can be effected by varying the impeller speed and/or the pressure in the impeller housing.

Comparisons of the various results indicate that these three variables are related in that each represents an effective method for controlling the rate of aeration in the cell. It appears probable that different mechanisms are operative for froth and kerosine flotation and direct comparisons of these processes are to be undertaken.

Most of the tests reviewed were made with a standard 24-in. by 24-in. unit cell of the sub-aeration type. The diameter of the impeller was approximately 12 in. and the recommended speed of operation was 700 r.p.m. The cell had a rated volume of 12 cu. ft. and was fitted with a perforated scraper-drag assembly for removing the float product. Accessory equipment included an apron-type dry-coal feeder, a constant-head water supply, reagent feeders, a centrifugal pump for delivering coal, water, and reagents to the cell, and a similar pump for disposing of portions of the float and refuse products to an outside settling tank.

In practice air-dry coal, water, and reagents were fed at pre-determined rates through a shallow pan-type intake to a centrifugal pump connected to the standpipe of the flotation cell by approximately 15 ft. of 1-in. galvanized pipe. Although the omission of a conditioner from the circuit and use of air-dry coal represent departures from commercial practice any attendant disadvantages were believed to have been largely offset by the intense agitation to which the feed was subjected during passage through the feed pump.

In developing suitable operating procedures, the authors say, it was necessary to determine the time required to establish equilibrium conditions after the start of a test. To accomplish this the cell was filled to the desired level with water and reagents, the coal feed turned on, and timed increments of float coal *plus* grab samples of tailings taken for the next 14½ min., at which time the coal feed was shut off and increments taken thereafter for an additional 2½ min. The results indicate the following :—

(1) The solids content of the float product was constant after 1½ min.

(2) The flotation rate increased only slightly after 1½ min. and was constant after 6 min.

(3) The solids content of the refuse product increased continuously throughout most of the run, reaching the expected value of 11·4% based on the quantity of feed and float material after approximately 13 min.

In addition to the flotation tests with the unit cell a four-cell pilot plant was installed in the fine-coal cleaning circuit at the Flat Top washer of the United States Pipe and Foundry Company. This unit consisted of four series-connected cells of the same size and type as that used for the single-cell tests. The four-cell machine, however, had, in the manufacturer's terms, conical-disc impellers with flat wearing plates, whereas the single cell had the receded disc impeller and diffuser. All impellers for this machine were operated at approximately 600 r.p.m.

At Flat Top the raw coal is wet-screened on a vibratory screen and the undersize (*minus* 14 mesh) is flumed to an inverted cone that discharges into the plant conditioner, where kerosine is added, the conditioned pulp flowing by gravity to three banks of flotation cells. Feed for the four-cell pilot plant was obtained by installing an adjustable orifice at the apex of the cone to maintain a substantially constant level within the cone and by cutting a hole through the side about 6 ft. below the surface and welding a 2½ in. diameter pipe nipple to it at an angle that would allow the pulp to flow by gravity to a 30-gal. drum fitted with a high-speed stirrer and used as a conditioner. The feed rate to the drum was controlled by inserting a series of various diameter pipes, the smallest inserted into the next larger size and so on, through the welded nipple into the centre of the plant cone, thereby withdrawing a quantity of pulp in proportion to

the internal diameter of the smallest pipe used and the pulp level in the cone.

The bulk of the reagents was also fed to the conditioner, which discharged directly into the feed pipe of the No. 1 cell of the pilot plant. The remainder of the reagents was fed to the intake of the No. 3 cell. It should be recognized that conditioning was momentary.

Results obtained with the unit cell show that float-coal recoveries may be used as valid measures of cell performance, regardless of whether expressed as weight per unit time or per cent. of feed. However, when expressed in the latter units, results may be compared directly, even for different cells, coals, and feed rates, and are therefore preferable for the purposes of this discussion. Inspection of the data shows that, except for a single pair of tests at relatively high solids contents, use of the various impeller restrictions yielded marked increases in recovery. The results obtained at high solids contents suggest that in commercial operations application of rings will be beneficial, principally for cells in which the pulp density does not exceed some limiting value, probably around 15%, although slight improvements have usually been noted, even at higher solids contents.

As the increased recoveries and flotation rates obtained with the unit cell were large enough to have considerable practical significance, confirmatory data were sought for series-connected cells operated on a typical plant flotation feed, as already noted. Tests were made using various numbers and sizes of rings in this pilot plant and the feed was adjusted to the maximum tonnage that could be effectively cleaned when 17 in. diameter rings were used in all cells.

Probably the most striking indication of the effects of rings on cell capacity is obtained by computing recovery factors for the individual cells as follows :—

$$\text{Recovery factor} = \frac{100 \times \text{float coal recovered, lb./hr.}}{\text{Floatable coal fed, lb./hr.}}$$

The results for the various cells indicate increases in the recovery of floatable material fed to the individual cells ranging from approximately 4 percentage points in cell 1 to 38 percentage points for cell 4.

The results obtained with the unit cell did not readily permit conclusions as to the effects of rings on the ash content of the float coal at any given level of recovery. A graphical analysis of the pilot-plant data does, however, yield some information on this subject. Inspection of the data indicates that, when the cells were equipped with rings, the recovery of ash corresponding to any given recovery of float coal was approximately 2 percentage points lower than that noted when rings were not used. Although individual differences were small, amounting to approximately 0·2% ash in the cleaned coal, taken together the results indicate significant improvements in the efficiency of separation.

In the previous report a few data were presented indicating that, contrary to expectations, supercharging resulted in marked decreases in recoveries. Inasmuch as a logical extension of this finding suggested that suppressed aeration might lead to increased recoveries, a number of tests were made with the unit cell in which the various openings in the impeller housing and feed standpipe were closed. Inasmuch as the feed was transferred to the cell by means of a pump with submersed intake, the only air entering the cell was that entrained in the feed and that which leaked through the packing glands. Measurements taken at the feed standpipe and impeller housing indicated pressure differentials to the atmosphere of around 5 in. of mercury. The results data indicate that increases in recovery similar to those obtained *via* impeller restrictions can be achieved by closing the air intakes to the cell for tests using moderate feed rates and pulp densities, decreased recoveries again being noted when supercharging was used.

As the rates of aeration obtained in sub-aeration-type cells are directly related to impeller speeds further tests were made with the unit cell, using speeds ranging from 0 r.p.m. to 710 r.p.m., all other conditions of operation being normal. The results here indicate that recoveries increased with increased impeller speeds reaching a maximum at about 430 r.p.m., beyond which further increases in speed resulted in decreased flotation rates and recoveries. The speed corresponding to maximum recovery was only slightly more than half the 700 r.p.m. recommended for normal operation of the particular cell used. The increases in recovery caused by reducing the impeller speed from the recommended value of 700 r.p.m. to the optimum value of around 430 r.p.m. were similar to those obtained by using rings or suppressed aeration. The solids contents of the float products appear to be directly related to the level of recovery and independent of impeller speed, except in so far as variations in impeller speed influence the level of recovery. Thus maximum values for the percentage of solids in the float products were noted at impeller speeds corresponding to maximum recoveries, lower solids contents being noted for either higher or lower speeds.

The observed effects of supercharging and suppressed aeration led directly to the study of variations in impeller speed as a more advantageous method of controlling aeration. Visual observation of the cell surface suggested that the use of rings was also effective because of their influence on the rate of aeration. To obtain information regarding this question an apparatus for measuring aeration at the cell surface was constructed and used to determine aeration rates for the unit cell under various conditions of operation. Results of measurements with water only passing through the cell indicate that using rings, closing air intakes, and reducing impeller speed to around 430 r.p.m. all have similar effects on the rate of aeration. This finding is consistent with the observation that, for a moderate throughput of feed containing around 10% solids, these three modifications yielded similar increases in flotation rates and recoveries and suggests that, for any given feed, there exists an optimum level of aeration and that as a close approximation it makes little difference as to the particular combination of operating variables—that is, supercharging, suppressed aeration, impeller speed, and/or rings—used to obtain this optimum level. To obtain confirmatory evidence for this conclusion additional unit-cell tests were carried out in which different combinations of operating variables were used to achieve selected rates of aeration.

For the series of tests using rings reducing the impeller speed below the recommended level of 700 r.p.m. resulted in relatively small increases in recovery. For the series using suppressed aeration

the recovery at an impeller speed of around 430 r.p.m., the optimum level for tests with normal aeration, was far less than that noted at 600 r.p.m., the highest speed included in the series. These findings indicate that the use either of rings or suppressed aeration reduces the rate of aeration to about the optimum level and that further reduction in aeration rates caused by reducing the impeller speed either has little effect or results in decreased flotation rates and recoveries.

In applying these conclusions to commercial installations, the authors say, certain factors should be emphasized : First, most of the results presented were obtained with feeds containing around 10% solids. The relatively few data available for feeds of other solids content indicate that the optimum level of aeration and/or the impeller speed required for a given level of aeration increases with increasing solids content. This suggests that each cell in a continuous unit should be individually adjusted to the optimum aeration rate for the average level of solids fed to that particular cell.

Secondly, it is recognized that the rate of aeration itself and not the means for adjusting it (as by varying impeller speeds, use of rings, supercharging, or suppressed aeration) is the primary variable controlling kerosine flotation rates for coal. Therefore, as the normal aeration rates of cells differ according to the type of cell used and the condition of the impeller, the particular combination of operating variables most suitable for achieving the optimum level of aeration cannot be stated but will vary from one unit to the next. As an example, a small continuous cell somewhat similar to those used in this study but having a capacity of only around 150 lb. per hour was furnished with a motor and drive mechanism which gave aeration rates very close to the optimum level without any modification.

Thirdly, theoretical studies of flotation rates and practical studies of power consumption during flotation indicate that the conclusions stated are probably applicable only when the reagents used include substantial quantities of oil inasmuch as comparison with results reported for ordinary froth flotation processes frequently indicated opposing relationships. Although direct comparisons of these processes will be presented in future reports, it now appears that kerosine flotation of coal takes place by a somewhat different mechanism from that applicable to ordinary froth flotation and that different rate-controlling steps are operative for these processes.

Finally, it is pointed out, it should be recalled that, in this report, recoveries expressed as percentages of weight fed are used as measures of flotation rates and cell capacities. The frequent references to increased recoveries are not intended to imply that the authors feel that increased total recoveries are necessarily desirable. Rather, these data show that significant increases in recovery per unit cell or battery are possible by operating under optimum conditions of aeration. Thus, by careful control of operating variables, it should in many instances be possible to effect the maximum desirable recovery of float product with fewer flotation cells than would be required if little attention is given to this phase of the operation. The corresponding decreases in cost per unit installation and operation, *plus* the slight improvements in efficiency of separation, should have considerable practical significance.

Manganese in Bombay State, India

In *Economic Geology* for December Supriya Roy describes the mineralogy of the manganese ores of Dongari Buzurg, an important manganese-producing area in Bombay State, and goes on to suggest a mode of genesis. The district in question is situated in a 130 miles long and 16 miles wide belt of manganese ore deposits that cross the two states of Madhya Pradesh and Bombay and includes a number of important deposits—such as, Tirodi, Sitapathor, Sukli, Sitasaongi, etc. This ore belt was studied in detail by Fermor, who indicated that the ores are associated with Precambrian metamorphic rocks in general and the gondites (principally spessartite-quartz rock with or without other manganese silicate) in particular.

The Dongari Buzurg manganese mine, which is closely associated with Chikhla and Sitasaongi mines within an area of 15 square miles, is characterized by the following rock formations :—

Chorbaoli formation (quartzites, quartz-muscovite schists).

Mansar formation (muscovite-biotite schist locally with staurolite).

Sitasaongi formation (feldspathic quartz-muscovite schist, quartzites).

Tirodi biotite gneiss.

These rocks are intercalated with streaks and massive bodies of gondites that in places are composed of spessartite and quartz only. In other cases manganese silicates are present in varying proportions. The manganese ores have two principal modes of occurrence : (1) As massive ore-bodies associated with the gondites and (2) as replacement bodies in the form of nodular kidney-shaped ores or cavernous and stalactitic bodies within the schists.

The peculiar and most important feature of the manganese ore deposits of Dongari Buzurg is their mode of occurrence and mineralogical assemblage, both of which class them as quite different from the other important manganese ore deposits situated close to it. These features—*i.e.*, the mineralogical assemblage, textural relationships, and the origin of this interesting ore body—are dealt with in detail in this paper.

The mineralogy of the manganese ores of Dongari Buzurg has been established mainly by microscopic study of polished sections under reflected light and also by X-ray powder analysis whenever there was any doubt about the conclusive identification of any mineral. The reflecting powers of the different minerals have been determined with the aid of Berek's slit microphotometer, using green light, and etching tests were carried out with the minerals to confirm their identification.

The study revealed the presence of the following minerals : Pyrolusite, manganite, cryptomelane

(+ psilomelane), coronadite, jacobsite, and braunite. Vredenburgite, the mixed mineral consisting of crystallographic intergrowth of jacobsite and hausmannite, is also present. Pyrolusite is by far the most abundant mineral, depicting different modes of formation. It occurs as randomly-oriented needles, well-developed crystals (some twinned), and colloform bands evidently deposited from colloidal gel. It occurs as primary interstitial mineral in braunites in massive gonditic ores and also as secondary replacement and alteration product of other primary minerals such as jacobsite, braunite, and manganite. Both fine and coarse grained varieties are present.

Manganite occurs mostly as fine needles altered to a great extent to pyrolusite, lining the vugs or randomly oriented on a psilomelane base. It occurs both in the colloidal ores and the massive gonditic ores, where it exhibits schistose texture with braunite and pyrolusite.

The various ores are characterized by different modes of occurrence and mineralogical assemblage and the general textural relationships also vary with them. In describing the texture of the ores, therefore, three broad divisions have been made according to the mode of occurrence of the particular ore suites :

(i) The hard massive ores associated with the gondites.

(ii) The cavernous, banded, kidney-shaped, and stalactitic ores as replacement deposits in mica schists.

(iii) A mixture of the hard, massive, gonditic ore, and the cavernous, kidney-shaped replacement ores.

In reviewing the texture and paragenesis of the minerals the role of jacobsite, the author says, should be emphasized. It occurs abundantly in the gonditic ores, in vredenburgites, or as individual grains free of hausmannite. The presence of irregularly scattered grains of jacobsite in later colloidal manganese dioxide minerals can be explained by the colloidal invasion in the earlier schistose ore, which was less compact than the recrystallized gonditic ore bands. A peculiar occurrence interbanded with cryptomelane and pyrolusite, however, could not be explained except by more or less contemporaneous deposition from a colloidal " gel," though such low-temperature of formation for jacobsite is rather improbable.

A primary origin for the gondites and the associated ore-bodies by metamorphism of manganese sediments has previously been postulated. Abundant manganese dioxide minerals extending to 400 ft. below the original surface outcrop and 250 ft. below the present water table have been formed by supergene oxidation of gondite and braunite. An ancient weathering cycle has been envisaged that brought about the supergene alteration and accumulation of this huge deposit of manganese dioxide ores, which were later somewhat enriched by the present weathering cycle.

The present author agrees as to the primary metamorphic origin of the gonditic ores, but his findings do not support the origin advocated for the cavernous, banded, kidney-shaped, botryoidal-stalactitic ores purely by oxidation and supergene enrichment. These ores, composed chiefly of manganese dioxide minerals, replace the schists abundantly and gondites to some extent and are accompanied by considerable amount of silica in the form of quartz, agate, and chalcedony. Cryptomelane and psilomelane form alternate concentric bands with agate or chalcedony in colloform deposition. The needles of pyrolusite and manganite oriented perpendicular to the vug boundaries or concentric rings of colloform psilomelane or cryptomelane, point to deposition in open space; shrinkage cracks, traversing laterally the concentric rings (formed evidently by surface tension in the original colloidal gel) of psilomelane and cryptomelane, suggest contraction during consolidation and deposition. Also the characteristic spherical nodules of psilomelane and cryptomelane, during close contact with one another, deformed each other mutually without breaking, which is convincing evidence that at the moment of their origin they were non-rigid bodies—*i.e.*, " gels." All this evidence indicates that an original colloidal nature of the material that gave rise to the botryoidal, kidney-shaped, and banded ore-bodies is the most probable explanation. The colloidal gel evidently invaded the highly foliated schists, taking advantage of the foliation, porosity, and the fault planes. The gondites and massive ore-bodies are also invaded by them and some sort of solution and leaching within the gondites has to be envisaged prior to the deposition. It is suggested that silica in the gondites might have been leached out and the colloidal gel was enriched with it.

Although some supergene enrichment of the massive gonditic ore by oxidation and weathering has taken place, as is evidenced by jacobsite, braunite, and hausmannite (in vredenburgite) altering to secondary pyrolusite and psilomelane, the total effect is so negligible that any substantial enrichment in the ore-body is unexpected. In the mixed colloidal and massive gonditic ores irregular grains of jacobsite are present where the colloform pyrolusite and psilomelane and cryptomelane have either included them or have moulded themselves along the boundary of the jacobsite. Thus, evidently the formation of the manganese dioxide ore was brought about by invading colloidal gel rather than just by enrichment *in situ* due to supergene oxidation or weathering.

Ore-Dressing Progress

An essay on developments in minerals beneficiation by Norman Weiss appears in *Mining Engineering* for January and the following notes are abstracted. The author suggests that decisive developments in minerals beneficiation in recent years may be classified as : (1) New techniques and processes, (2) the extension of older processes to new types of ores, and (3) improvement of costs. The first category, he says, is reflected in the technology of uranium-ore milling, with increasing employment of ion-exchange resins and solvent extraction. At the same time flotation is moving confidently into new areas. Mineral phosphates, tungstates, salines, fluorite, barite, quartz and some silicates, heavy minerals from beach sands, oxidized ores, iron ores, and coal are only a few of the natural minerals that

are now separated and concentrated by froth flotation. Reagentizing, or agglomeration by surface-active reagents, is in practical application on phosphate sands.

In base-metal mills improvement has been generally continuous, but in most cases there is still room for improvement. Every operation—crushing, storing, grinding, classifying, thickening, pumping, and conditioning—contributes to the constantly improving quality of base-metal separations. While new reagents have been few, there have been such outstanding advancements as the soluble glycol ether frothers and the use of oxidizing agents in molybdenite separations. The high molecular weight polymers now in wide use for flocculating suspended solids, though not strictly flotation reagents, have had indirect influence.

Gravity concentration has also made excellent progress in the last decade—to mention the Humphreys spiral, Cannon concentrator, and the Remer jig. Heavy-media separation has gained wider acceptance, while improvements in magnetic separations, both dry and wet, and high-tension concentration have good prospects for further advancement. Possibilities of crushing ore by tensile failure induced by high-frequency electromagnetic induction demonstrates that the evolution from new knowledge to application can occur overnight.

Automatic control, it is noted, has manifested substantial gains in the post-war period, aided by progress in the fields of nucleonics and electronics. Nearly every step of the milling operation, from crushing to tailing disposal, is now self-controllable or controllable from centrally-located consoles with feed-back information. The greater use of data-reduction equipment and statistical methods is a logical corollary to the increasing capability in the field of identifying and measuring process variables.

The writer says that he has reviewed the undergraduate minerals beneficiation curricula of leading mining schools in the United States. Trends are unmistakably toward better education in the basic sciences, more hours in the humanities, greater flexibility in professional subjects, and more emphasis upon learning to test, apply, and evolve new concepts rather than learn manual skills. However, educators recognize the existence of two basic and opposite schools of thought and find difficulty in either choosing or compromising between these attitudes. One group believes that traditional curricula are obsolete, while the other believes that the function of the engineer differs profoundly from that of the scientist, calling as it does for a variety of judgments and decisions foreign to the scientist's interests. The two chief concerns of the engineer are *cost* and *reliability* and these modes of thinking must be instilled in the student at the earliest possible stage of his development.

Metallurgical engineering, of which minerals beneficiation is a subdivision, can, the author says, no longer be considered a distinct subject. Old divisions of civil, electrical, mechanical, chemical, mining, and metallurgical engineering have become less distinct and more of the engineering curricula should be changed to accommodate this concept. Given a clear choice between *metallurgical science* and *metallurgical engineering* the undergraduate might receive a broader education without losing the advantages of specialization. Great advances will always come from the brilliant discoveries of a few men and these men of the future will come to maturity only in the graduate school, then go on to join the staffs of the colleges, or industrial and government laboratories, and become the scholars and intellectual leaders in every field.

For the most part there has not been sufficient development of high-quality graduate work and research in engineering. Two primary requirements are needed to bring about an excellent graduate division—money and talent. Money is needed for adequate buildings and equipment; for scholarships, fellowships, and research contracts for graduate students; and for enough additional compensation to faculty and research leaders so top-grade men can stay without personal sacrifice. The U.S. Government is taking upon itself much of the responsibility for improving and increasing educational facilities in the fields of science and engineering, but this does not relieve industry of its obligations. It will accomplish little good for industry to appropriate large amounts of money for industrial research if the link between new knowledge and new applications is too weak to carry the load. That link is the graduate school.

Trade Paragraphs

Engineering Materials and Design Exhibition

The Engineering Materials and Design Exhibition, the first of its kind to be held in this country, and sponsored partly by the *Financial Times*, is to take place at Earls Court, London, from February 22 to 26. The exhibition will afford an opportunity of examining a wide variety of new components, materials, and design ideas. Engineering materials to-day include minerals, plastics, textiles, inorganic materials, rubber, adhesives, refractories, ceramics, numerous sintered products and compositions, as well as timber, cement, and metals and alloys of all kinds, many of which are new or under active development. Many well-known manufacturers are taking part. In connexion with the exhibition there will be a conference for engineering designers held at the same time and in the same building. Lectures and papers will be presented from a number of authorities, whose subjects will include ferrous metals and alloys, light metals and alloys, insulating and other electrical engineering materials, powder metallurgy, inorganic materials, bearings, clutches, casting techniques, seals, drives, couplings, control techniques, and appearance design.

Heyes and Co., Ltd., of Wigan, state that the Scottish Division of the National Coal Board has placed an order for a 3-level, type 40, shaft signalling indicator system for installation at Arniston Colliery.

N.C.K. Rapier Sales Co., Ltd., of 32, Victoria Street, London, S.W. 1, issue a leaflet giving details of the Pennine heavy-duty crawler crane with digging attachments. Tables give lifting capacities at different radius dimensions and boom lengths.

Huntington, Heberlein and Co., Ltd., of Simon House, 28–29, Dover Street, London, W. 1, announce

that Mr. A. T. Rogers, technical director and chief engineer, and Mr. R. F. Jennings, technical director, have been appointed directors of the company.

Atlas Copco AB, of Stockholm, announce the merging of their Northern and Southern Rhodesian companies into one concern under the title of Atlas Copco Rhodesia (Pvt.), Ltd., in new premises in Salisbury, with branches at Bulawayo, Lusaka, and Ndola.

Sumo Pumps, Ltd., of 28, St. James's Square, London, S.W. 1, announce a new range of series " B " 4-in. submersible electric pumps. In the pump every impeller incorporates sand slinger vanes and a higher head per stage has been obtained by the use of impellers of larger diameter. The motor is the Clam-Seal type, introduced a year ago to operate in sand-laden water.

Rapid Magnetic, Ltd., of Lombard Street, Birmingham, have published an illustrated leaflet giving particulars of their overband magnetic separators which are automatically self-cleaning and can be used above continuous plant conveyor-belts, vibratory feeders, or other forms of carrier for the removal of loose iron and steel (tramp metal) in advance of crushing and grinding machinery which might otherwise be damaged.

Joy-Sullivan, Ltd., of Cappielow, Greenock, state that their new stable hole conveyor or " Miniveyor " has been designed to save manpower in making stable holes at the ends and in advance of mechanized long-wall faces. Existing methods, often calling for hand-casting of coal, are particularly inefficient on rapidly advancing faces, where delay in stable hole preparations can affect the turnround and reversal of loading machines and advance of conveyor gearheads and tailends.

Willis Instruments, Ltd., of Field Road, Busby, Lanarks., has been formed to manufacture gas-detecting instruments and alarms to certified and approved designs. They will also provide 24-hour servicing and maintenance facilities for all types of electrical and electronic scientific instruments. Mr. Alex. N. Willis, managing director of the new company, was until recently chief development engineer with Mine Safety Appliances Co., Ltd., Glasgow.

Hugh Wood and Co., Ltd., of Royal London House, Finsbury Square, London, E.C. 2, recently took part in the War on Want exhibition held in London. For the occasion they produced an illustrated brochure on the importance of the conveyor, which contains many examples of its application, and also a 75-page booklet giving a list of the company's products that " are making a contribution to reviving the standards of living," which is well furnished with photographs.

Polypenco, Ltd., of 68–70, Tewin Road, Welwyn Garden City, Herts., issue a leaflet describing Nylaflow pressure hose and tubing suitable for lubrication lines, caustic and dilute acid lines, as well as air and hydraulic lines. A table gives dimensions and pressure resistances. The hose is obtainable in two alternative burst-pressure ratings of 5,000 p.s.i. and 8,000 p.s.i. A separate leaflet gives brief details of a number of other plastics products with their properties and applications.

D.R. Illuminations, Ltd., of Leestone Road, Wythenshawe, Manchester, draw attention to their floodlighting equipment for use several hundred feet below water level without any adverse effect. It comprises a fibreglass lightweight reflector giving cut-off characteristics over a wide plane, a neoprene lampholder to Admiralty specification, automatic assembly, scaffold clamp, trailing lead and waterproof coupler, a hard glass lamp (500, 750, or 1,000 W), and coloured parts for identification.

Griffin and George, Ltd., of Ealing Road, Alperton, Wembley, Middx., announce the production of the first of the new series of balances designed for general purposes but incorporating analytical features. It is the Griffin Minor which has a short beam for speedier weighing, single-limb bows carrying the weighing pans, an inclined scale which rises with the pointer facilitating reading and avoiding parallax, a unique design in stirrups to protect knife edges, and a new design of pillar which allows easy and rapid assembly.

Cyanamid International, of 30, Rockefeller Plaza, New York (British representatives: Cyanamid of Great Britain, Ltd., Bush House, London, W.C. 2), have compiled an illustrated booklet on their flocculents, the various types and properties of which are listed. The other contents comprise general information, field of application, anti-precipitant usage, improvement in both thickening and filtration rates, toxicity, preparation of feeding, feeding methods, dosage rates, suggested laboratory testing methods, filtration testing, and commercial applications—uranium operations, coal preparation, non-metallic flotation concentrates, and cyanidation.

Steel and Co., Ltd., of Crown Works, Sunderland, has made an agreement with Unit Crane and Shovel Corporation, of Milwaukee, whereby Unit will manufacture Coles cranes in Milwaukee and will market these throughout the U.S.A., Canada, and Mexico under the names of Unit-Coles. R. H. Neal and Co., Ltd., will manufacture Unit cranes, excavators, draglines, and backhoes in Grantham and will market them throughout the world with the exception of U.S.A., Canada, and Mexico under the name of Neal-Unit and subject to the existing Unit franchises in Australia, Union of South Africa, and the Benelux countries. A sales company has been registered under the name International Crane and Excavator Corporation with headquarters in New York for marketing Coles cranes and Unit cranes and excavators in the South and Central American Republics.

Johnson, Matthey and Co., Ltd., of Hatton Garden, London, E.C. 1, have for some years produced the rare earths and recent research into the application of ion-exchange techniques to the separation of these materials has made them available in large quantities, in various grades of purity, and at much lower cost than hitherto. New techniques have also been applied to the production of the rare earth metals and all the 14 " lanthanons " that occur naturally and the related elements scandium and yttrium are now available in a state of high purity. All the 16 metals have been re-melted into ingots or rods. Lanthanum, cerium, neodymium, praseodymium, yttrium, and gadolinium have been successfully extruded and subsequently drawn to fine wire. A publication just issued describes the properties, characteristics, and availability of this potentially valuable range of materials.

United Steel Companies, Ltd., of 17, Westbourne Road, Sheffield, issue some notes on a new British tunnelling record of 107 yd. 4 in. in seven days at the Bank Hall colliery, Burnley, in the North-Western Division of the N.C.B. The Towneley tunnel, in which the new record was established,

has a sectional area of 21·5 sq. yd., is 1,500 ft. below ground, and about 5,000 ft. from the shaft, and the driving was through shale, sandstone beds, and cannel, about 4,700 tons of debris being removed from the pit in this week in addition to an output of 7,213 tons of coal. The drivage was carried out by six face men per shift, using six Holman Silver Three drills equipped with Padley and Venables 10-ft. drills and tungsten carbide tipped bits. The broken ground at the face was removed by a Distington-Goodman 50 B. tunneller. This 12-ton, 70-h.p. machine has been in service at Bank Hall colliery since June, 1957. The spoil was then loaded into 4½-ton mine cars, which are also of Distington Engineering Company's manufacture.

Imperial Chemical Industries, Ltd., of Millbank, London, S.W. 1, announce that Terylene reinforced premium V-belts are now available from many leading manufacturers. They are already being used in widely varying conditions, from ½-h.p. machines up to 600-h.p. compressors. In most cases they have lasted twice and in some cases five times as long as standard belts. Because Terylene is so strong it has often been possible to use fewer individual belts on existing drives, while future drives, designed to incorporate fewer belts, may mean considerable savings in space and cost. From their Nobel Division the company have issued a booklet on Seismex, an explosive developed particularly for use in seismic prospecting. The complete equipment comprises the explosive, packed in tinplate can, the primer, similarly packed, the plastic detonator shield, a loading point centralizer, and electric detonators and wiring. Methods of use are described and illustrated.

Rocol, Ltd., of Rocol House, Swillington, near Leeds, have issued a new technical publication which gives applications of their molybdenized lubricants to mining and associated equipment. Anti-scuffing paste has the widest use as an assembly and anti-seize lubricant which will overcome the difficulties of stripping down units which have been in service under conditions of wet and dust. When anti-scuffing oil is added to existing lubricating oils overheating, wear, and seizure in trouble spots, such as overloaded gearboxes and hot ring oil bath bearings, are eliminated. Molytone greases combat wear and seizure under starved or other arduous lubrication conditions as experienced with pit prop pivots and certain types of conveyor and motor bearings. Where conventional lubricants cannot be employed because they would become contaminated with dust to form abrasive pastes, such as with conveyor chains and sprockets and chain slides, the dry lubricant Molytox Plus solves the problem, it is suggested.

Hunting Surveys, Ltd., of 6, Elstree Way, Boreham Wood, Herts., announced last month that the activities of Hunting Geophysics, Ltd., have been merged with those of Hunting Aerosurveys, Ltd., under the above title. The two other companies in the British division of the Hunting Survey Group, Hunting Technical Services, Ltd., and Aerofilms, Ltd., will continue to work in close association. Similarly the activities of the Photographic Survey Corporation, Ltd., Hunting Airborne Geophysics, Ltd., and Hunting Technical and Exploration Services, Ltd., have been combined under the name of Hunting Survey Corporation, Ltd., in Canada. A separate announcement states that the Directorate of Overseas Surveys has commissioned two aerial photographic contracts in Nigeria and Sierra Leone involving an area of 18,000 sq. miles. The company awarded the contract is the Aircraft Operating Company, Ltd., of Johannesburg, the South African associate of the Hunting Survey Group. The Aircraft Operating Company has worked in West Africa since 1946 and will use two aircraft on the contract to get full advantage of the limited number of days on which photography is possible.

English Electric Co., Ltd., of Stafford, announce that an order for what are believed to be the largest converter-fed winders in the world has been received from Consolidated Gold Fields of South Africa, Ltd. The two winders, each of 6,000 h.p., will be installed at the West Driefontein and Doornfontein mines respectively. They are also believed to be the first to operate on a very high voltage system. The winder converter transformers will be directly connected to the 40-kV grid, which has a prospective fault capacity of 1,000 MVA. A major factor in the decision to use mercury-arc converter equipment instead of Ward-Leonard for a winder of this size, it is stated, was the lower cost. With Ward-Leonard control it would have been necessary to introduce special step-down transformers and additional switchgear for the a.c. motors driving the motor-generator sets, but with a converter feed the main transformer can be wound to suit the highest supply voltage available.

The double-drum winders, mounted on the surface, will have balanced skips with a payload of 10 short tons and an output of 277 tons per hour from a depth of 6,000 ft. when winding at a rope speed of 3,600 ft. per minute. Each drum will be 16 ft. in diameter and 6 ft. wide, the rope being of 2 in. diameter. The motors will have a full load speed of 70 r.p.m. and will be capable of a full load peak of 12,000 h.p. necessary for the 20-sec. accelerating period at the beginning of each wind. The magnet frames will be laminated for the field-reversal type of control system. Control will be push-button automatic or manual according to need. This is achieved by the use of magnetic amplifiers, all phases of operation being monitored. The converter equipment for each winder will have a rating of 4,800 kW and will be connected for 12-phase operation. A maximum electrical retarding torque equivalent to nearly 10,000 h.p. will be available. Because of the atmospheric variations temperature-control equipment will be provided. The converter and auxiliary transformers as well as the 1,000-MVA oil circuit breaker will be mounted outdoors.

G.E.C. Activities in 1959

From the General Electric Co., Ltd.'s annual review the following extracts are of interest: The most important item in this is the reference to an order from Japan to build the first nuclear power station in collaboration with Simon-Carves, Ltd. An overseas nuclear agreement was also concluded with Maschinenfabrik Augsberg-Nurnberg (M.A.N.) of Germany.

General Engineering.—The period under review has been one of intense activity in the production of winding engines with 16 electric winders commissioned during 1959, four of them overseas and 12 in the U.K. for the National Coal Board. Among those put into service overseas was a 4-rope friction winder at the Stilfontein Mine of the General Mining and Finance Corporation, which hoists a load of

15 tons from a depth of 4,800 ft. This is believed to be the greatest depth to which any friction winder is operating. Included in the numerous orders received from the N.C.B. were two that used grid-controlled mercury-arc rectifier-inverters to provide the speed control system.

During the year one of the largest single-unit coal-preparation plants in this country was commissioned at the Hawthorn Combined Mine of the N.C.B. It deals with an input of 750 tons/hour with the larger fraction cleaned by the well-known Chance sand flotation system and the fines by froth flotation.

Power Distribution.—In the sphere of power distribution a dominant feature has been the continued demand for airbreak switchgear for 3·3-kV service. Orders for switchboards of this type rated at 250 MVA breaking capacity are in hand for Tallawara and Wallerawang, Australia, and similar equipment rated at 150 MVA is being built for Mount Isa Mines. Plug-in distribution equipment in the form of motor control centres and power distribution centres for service at medium voltages continues to be in demand.

An entirely new range of medium-voltage a.c. switch-fuses, known as the " Hidutac " range, has been introduced. The design represents a complete break-away from previous conceptions of small switchgear. Major advances include high current-breaking capacity, high fault-current protection, greatly reduced size and unlimited full-load switching. There is also a new range of hydraulically-operated oil circuit breakers for 33-kV service which is now in production.

Development work has continued on very high-voltage transformers and during the year a large 3-phase experimental transformer was successfully tested at an impulse voltage of 1,750,000 volts, which corresponds to a service voltage of over 380 kV. In an effort to establish the design safety margins the voltage was increased to a level far in excess of the normal flashover voltage of the bushings. This was achieved by enclosing the bushing in an envelope containing an electro-negative gas.

In some separate notes the company refer to a 72 in. by 60 in. Pennsylvania-Dixie non-clog hammer mill, described as the largest of this type ever built in Britain, for installation in the quarry of Adelaide Cement Company, Ltd., South Australia. It is capable of taking pieces of rock as large as 48 in. and breaking them all below 1 in. at the rate of over 350 tons per hour. It is shown in the illustration.

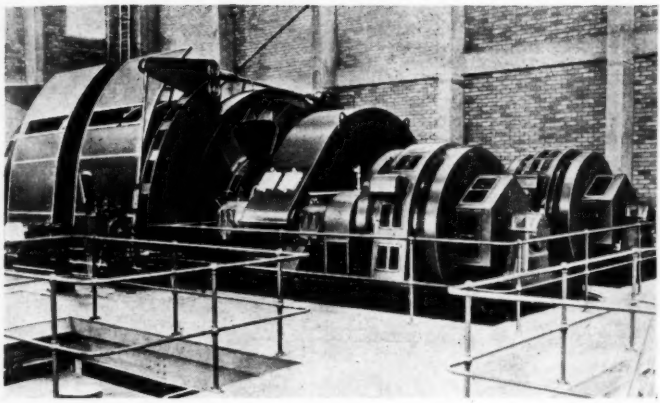
A.E.I. Progress in 1959

From an extensive annual review issued by Associated Electrical Industries (Rugby), Ltd., the following extracts are taken :—

Mining Equipment.—During the year a number of orders for winders using mercury-arc converters were received. These include a 1,400-h.p. winder which has a manual closed-loop control system. It is scheduled for operation in the No. 5 shaft of the N.C.B. Hucknall No. 2 colliery. An order has been received from the Selection Trust Group for a winder in No. 14 shaft at Mufulira West Mine. This winder, which will be driven by two 3,325-h.p., 350-r.p.m., 720-volt d.c. motors, will be installed during the latter half of 1960. The order includes a 4,800-h.p., 500-r.p.m. synchronous motor to drive two 2,400-kW generators supplying this winder.

A service winder for No. 12 shaft has also been ordered. The equipment will comprise a Ward-Leonard controlled balanced skip winder, driven by two d.c. motors with a total r.m.s. rating of 2,650 h.p. The winder has two clutched drums connected to the motor through single-reduction gears. The direct current will be obtained from a single M-G set, consisting of two 925-kW d.c. generators driven by a 2,025-h.p., 11-kV a.c. salient-pole

Pennsylvania-Dixie Hammer Mill



Winder Drive at Vaal Reefs

solid-pole motor. This will be fitted with reactor-type starting equipment. The mechanical parts will be supplied by **Fullerton, Hodgart, and Barclay, Ltd.**

Selection Trust has also ordered a winder for Peterson No. 2 shaft at Mufulira and manufacture is in progress of the 2,150-h.p. winder motor and 1,560-kW motor-generator set.

The Anglo American Corporation of South Africa have placed an order for Western Reefs (No. 4 shaft) for a 5,200-h.p. a.c. winder with dynamic braking. Several identical winders, the largest of their kind, have already been supplied to this company. The winder has twin motors controlled by a liquid rotor resistance. The A.E.I. system of transductor-controlled compensated dynamic braking is used. A.E.I. Export, Ltd., is the main contractor for the complete winder installation and mechanical equipment is by Vanderbijl Engineering Corporation, South Africa, to a design of **Vickers-Armstrongs (Engineers), Ltd.** This is a 16-ft. diameter drum with two compartments, both clutched, each 6 ft. wide and employing four layers of rope.

An order has also been placed by General Mining, on behalf of the Stilfontein Gold Mining Company (Scott Shaft), for a 5,200-h.p. a.c. winder with dynamic braking. Like the winder for the Western Reefs No. 4 shaft it has twin motors controlled by a liquid resistance and uses the A.E.I. system of compensated dynamic braking. The same sub-contractors are responsible for the mechanical equipment, which is also identical to that ordered for the Western Reefs No. 4 shaft.

In South Africa the largest twin-motor winder ever manufactured has been successfully commissioned at Saaiplaas for New Consolidated Gold Fields, Ltd. This winder, which operates on the Ward-Leonard principle, is the first in the Union to employ " Lamex " closed-loop control. It has a total r.m.s. rating of 6,700 h.p. and a peak rating of 14,200 h.p. A duplicate winder is being commissioned at the same mine.

At Great Boulder Gold Mines in Australia the first of two 1,100-h.p. Ward-Leonard " Lamex " closed-loop winders has been commissioned. This is the first of its kind in Australia.

Large and Medium Motors.—Two 2,000-h.p., 600-r.p.m. synchronous motors have been ordered by the Anglo American Corporation of South Africa, Ltd., for use in the V5 shaft and N'Kana No. 6 shaft at Mindola. These motors, which are suitable for switching direct to the 11-kV supply at 3-phase 50 cycle, will drive axial-flow fans manufactured by the Airtec Engineering Co. (Pty.), Ltd.

Another motor for mine-ventilation purposes has been ordered by the N.C.B. for Shireoaks Colliery, in the Board's North-Eastern Division. This motor, rated 444 h.p., 750 r.p.m., 3·3 kV, is being supplied with stator switchgear and starting and excitation control gear and is to be delivered in seven months from the placing of the order.

Blowers and Compressors.—The three large compressors, each rated at 25,000 cu. ft. of free air per minute, will supply air at a discharge pressure of 100 p.s.i.g. They have been ordered by the Anglo American Corporation of South Africa, Ltd., for installation in two gold mines, Western Deep Levels and Vaal Reefs, and are of a newly-developed standard design for A.E.I. air-compressors. The impellers for the six stages of compression are arranged back-to-back in pairs on the shaft, thus shortening the length of the machine, reducing end thrust, and thereby producing a better mechanical design. These machines are already in an advanced stage of manufacture and should be despatched to South Africa early in 1960.

Power Rectifiers.—Norway's largest producer of aluminium, Ardal og Sunndal Verk, who plan to increase their capacity by 32,000 tons a year, has ordered germanium rectifiers with a total output of 108 MW, 800 volts, 135,000 amps. for electrolytic smelting. For copper refining the total capacity of the equipments supplied now exceeds 11,000 kW. The latest order, from Semcongo for Union Minière du Haut Katanga in the Belgian Congo, is for two installations, each rated 810 kW, 45/20 volts, 18,000 amps.

Rectifier equipments despatched during the year include eight pumpless mercury-arc units for mine-winder drives, seven of them for the N.C.B. The

transformers for all of these rectifiers are non-inflammable fluid filled. The eighth equipment is rated 816 kW, 800–0–800 volts, 1,020 amps. r.m.s. and is to the order of New Consolidated Gold Fields for Venterspost mine, where it will be installed underground. Three single-tank mercury-arc rectifiers for dynamic braking of a.c. winder drives were despatched during the year, two for the N.C.B. and one for Strathmore Gold Mines, South Africa.

Industrial Drives and Control (*Mining*).—Overseas mining business has shown some increase and includes a contract for forty 50-h.p. flameproof squirrel-cage motors (Type KF) required for driving underground conveyors which are being supplied by the **Mining Engineering Co., Ltd.,** to the National Coal Development Corporation of India. Selection Trust, Ltd., have placed new business on behalf of Mufulira Copper Mines, Ltd., who require four 365-h.p., 1,470-r.p.m. squirrel-cage motors (Type RSP) for primary gyrator crushers. For Roan Antelope Copper Mines, Ltd., the group require two 1,660-h.p., 1,475-r.p.m. squirrel-cage motors (Type AMS) for pump drives. The Anglo American Corporation of South Africa, Ltd., have ordered a 1,000-h.p., 1,485-r.p.m. slipring motor (Type AMW) for the N'Changa Consolidated Copper Mines, Ltd.

Metal Industries.—Another order has been received from Huntingdon Heberlein and Co., Ltd., for a sinter-plant drive. The electrical equipment for this is made up of d.c. drive motors, contactor control gear, and magnestat equipments. This drive will be ultimately installed at Cockle Creek, Australia.

NEW BOOKS, PAMPHLETS, ETC.

☛Publications referred to under this heading can be obtained through the Technical Bookshop of *The Mining Magazine*, 482, Salisbury House, London, E.C. 2.

Asbestos : Its Origin, Production, and Utilization. By W. E. SINCLAIR. Second edition, revised and enlarged. Cloth, octavo, 512 pages, illustrated. Price 60s. London : Mining Publications, Ltd.

Industrial Minerals and Rocks (Nonmetallics other than Fuels) : A.I.M.E. Seeley W. Mudd series. Third edition, completely revised. Cloth, large octavo, 934 pages, illustrated. Price 105s. New York : American Institute of Mining, Metallurgical, and Petroleum Engineers.

The Lead Storage Battery. By H. G. BROWN. Fourth edition. Cloth, octavo, 166 pages, illustrated. Price 24s. Altrincham, Cheshire : John Sherratt and Son.

A Study of Granulators Used in the Production of Roadmaking Aggregates : Road Research Technical Paper No. 44. By F. A. SHERGOLD. Paper covers, 70 pages, illustrated. Price 5s. 6d. London : H.M. Stationery Office.

Towards a New Energy Pattern in Europe : Report of the O.E.E.C. Energy Advisory Commission. Paper covers, 125 pages. Price 9s. Paris : Organization for European Economic Co-operation.

Safety in Mines Research, 1958. Paper covers, 71 pages, illustrated. Price 5s. London : H.M. Stationery Office.

Bibliography and Subject-Index of South African Geology, 1957. Paper covers, 60 pages. Price 3s. 6d. Pretoria : Department of Mines.

Canada, 1959 : The Official Handbook. Paper covers, 317 pages, illustrated. Price $1.00. Ottawa : Dominion Bureau of Statistics.

Summary of Developments in the Canadian Mineral Industry, 1958. By B. F. BURKE. Paper covers, 33 pages. Ottawa : Department of Mines and Technical Surveys.

Sierra Leone : Report of the Mines Department, 1958. Paper covers, 22 pages, illustrated. Price 2s. 6d. Freetown : Mines Department Headquarters.

India : General Report of the Geological Survey of India for the Year 1954. By M. S. KRISHNAN : *Records*, Vol. 88, Part 1, 1958. Paper covers, 386 pages. Price 7s. Delhi : Manager of Publications.

Ceylon : Geology of the Country around Polonnaruwa (1-in. Geol. Sheet 47, Preliminary Series). Geol. Surv. Memoir No. 1. By PIYADASA W. VITANAGE. Paper boards, 75 pages, illustrated with maps. Colombo 2 : Department of Mineralogy.

Geology and Mineral Deposits of the San Fernando Quadrangle, Los Angeles County, California : Calif. Div. Mines Bulletin 172. By G. B. OAKESHOTT. Paper boards, 147 pages, illustrated, with maps. Price $3.75. San Francisco : Department of Natural Resources.

The Case-Hardening of Nickel-Alloy Steels. Paper covers, 36 pages, illustrated. London : Mond Nickel Co., Ltd.

The Report of the National Chemical Laboratory, 1958. Paper covers, 97 pages, illustrated. Price 5s. 6d. London : H.M. Stationery Office.

British Columbia : Minister of Mines Annual Report, 1958. Paper covers, 185 pages, illustrated. Victoria : Department of Mines.

New South Wales : Department of Mines Annual Report, 1957. Paper folio, 92 pages. Price 8s. Sydney : Government Printer.

Transvaal and Orange Free State Chamber of Mines : 69th Annual Report, 1958. Cloth, 99 pages. Johannesburg : Chamber of Mines.

RECENT PATENTS PUBLISHED

☛A copy of the specification of the patents mentioned in this column can be obtained by sending 3s. 6d. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.

7,137 of 1955 (825,443). BRITISH ALUMINIUM CO., LTD. Electrolytic three-layer cells for the refining of aluminium.

13,010 of 1956 (826,150). POWER JETS (RESEARCH AND DEVELOPMENT), LTD. Machine for breaking up wet and sticky material.

19,132 of 1956 (825,872). I. EGAMI. Electrolytic production of magnesium.

10,782 of 1957 (825,440). H. DOHMEN. Briquetting of ores.

6,975 of 1958 (825,272). BAHCO A.B. Centrifugal classifiers.

10,497 of 1958 (825,035). METALLGESELLSCHAFT A.G. Seals for the gas hoods of sintering machines.

Selected Index to Current Literature

This section of the Mining Digest is intended to provide a systematic classification of a wide range of articles appearing in the contemporary technical Press, grouped under heads likely to appeal to the specialist.

* Article in the present issue of the MAGAZINE. † Article digested in the MAGAZINE.

Economics

Boron, Review : *Production, Uses.* Boron. T. H. H. SKEET, *Mine, Quarry Engg.*, Feb., 1960.

Coal, United Kingdom : *Industry, Review.* Flexibility in the Coal-Mining Industry. R. G. BAKER, *Trans. Instn. Min. Eng.*, Jan. 28, 1960.

Production, Australia : *Uranium, Queensland.* The Mary Kathleen Uranium Project. A. NELSON, *Mine, Quarry Engg.*, Feb., 1960.

***Production, Canada :** *Asbestos, Review.* Asbestos in Canada. H. G. JARMAN, THE MINING MAGAZINE, Feb., 1960.

Production, Dominica : *Mineral, Review.* Mining in the Dominican Republic. *Mine, Quarry Engg.*, Feb., 1960.

Production, Japan : *Industry, Coal.* Coal Mining in Japan. H. A. J. DONEGAN, *Coll. Engg.*, Feb., 1960.

Production, Southern Rhodesia : *Lithium, Beryl.* A Description of Bikita Minerals Mining Operations. R. SYMONS, *S.R. Chamber of Mines J.*, Dec., 1959.

Resources, Australia : *Exploration, Tasmania.* The Search for Minerals in Western Tasmania. G. HALL, *Chem. Engg. Min. Rev.* (Melbourne), Dec. 15, 1959.

Resources, South Africa : *Coal, Natal.* Northern Natal Coalfield (Area No. 2) : The Utrecht Area.—Records of Boreholes Drilled for the Department of Mines. *S. Afr. Geol. Surv. Bull.* 29.

Geology

***Conglomerates, Auriferous :** *Origin, South Africa.* The Present State of the Witwatersrand Controversy. C. F. DAVIDSON, THE MINING MAGAZINE, Feb., 1960.

Copper, Northern Rhodesia : *Petrology, Study.* Petrology of Some Rhodesian Copperbelt Orebodies and Associated Rocks. A. G. DARNLEY, *Bull. Instn. Min. Metall.*, Jan., 1960.

Economic, Canada : *Silver, B.C.* The Geology of Torbrit Silver Mine. F. A. CAMPBELL, *Econ. Geol.*, Dec., 1959.

†Economic, India : *Manganese, Bombay.* Mineralogy and Texture of the Manganese Ore Bodies of Dongari Buzurg, Bhandara District, Bombay State, India, with a Note on Their Genesis. S. ROY, *Econ. Geol.*, Dec., 1959.

Exploration, Australia : *Mineral, Queensland.* Mineral Exploration in Queensland. A. NELSON, *Mine, Quarry Engg.*, Jan., 1960.

Regional, Asia : *Description, Hong Kong.* The Geology of Hong Kong. B. P. RUXTON, *Q. J. Geol. Soc.*, Vol. CXV, Part 3.

Regional, United States : *Coast Range, California.* Geologic Sketch of the Southern Coast Ranges. G. B. OAKESHOTT, Calif. Div. Mines Mineral Information Service, Jan., 1960.

Survey, Geophysics : *Aeromagnetic, Review.* Geological Appraisal of Aeromagnetic Surveying. G. W. COCHRANE, *Chem. Engg. Min. Rev.* (Melbourne), Nov. 16, 1959.

Metallurgy

Hydrometallurgy, Nickel : *Residues, Thickening.* Thickening Leach Residues in Sherritt Gordon's Nickel Refinery. D. J. I. EVANS, S. C. LINDSAY, *Min. Engg.*, Jan., 1960.

Pelletizing, Ore : *Study, United States.* Gathering Process Data. G. A. HANSEN, Allis-Chalmers Electrical Review, Fourth Quarter, 1959.

Rare-Metals, Separation : *Hafnium, Zirconium.* Zirconium-Hafnium Separation. W. A. STICKNEY, *Rep. Inv. U.S. Bur. Min.* 5499.

Smelting, Electric : *Stirring, Induction.* Inductive Stirring in Arc Furnaces. E. HAMMARLAND, B. HANAS, *Iron, Coal Tr. Rev.*, Feb. 5, 1960.

Smelting, Flash-Bed : *Furnace, Design.* Electric Flash-Bed Reducing Furnace : Experience in West Germany. *Iron, Coal Tr. Rev.*, Jan. 8, 1960.

Machines, Materials

Bits, Rotary : *Temperatures, Drilling.* Bit Temperatures in Rotary Drilling. J. E. WHITBREAD, *Coll. Engg.*, Jan., 1960.

Drills, Rotary-Percussive : *Study, Laboratory.* A Laboratory Study of Two Percussive-Rotary Drilling Machines. G. A. GUPPY, *Mine, Quarry Engg.*, Jan., 1960.

Ropes, Winding : *Inspection, Electronic.* The Theory and Practice of Electronic Testing of Winding Ropes. T. HARVEY, H. W. KRUGER, *Trans. S. Afr. Inst. Elec. Eng.*, June, 1959.

Steel, Stainless : *Uses, Mining.* How to Select Stainless Steel for Use in the Mining Industry.—Part II. R. E. PARET, *Engg. Min. J.*, Jan., 1960.

Tractors, Crawler : *Uses, Mining.* Crawler Tractors—3. J. M. CAW, *Mine, Quarry Engg.*, Feb., 1960.

Wheels, Motorized : *Uses, Mining.* Motorized Wheel Provides a New Tool for Solution of Haulage Problems. J. C. PRICE, R. W. VOLPE, *Min. World* (San Francisco), Jan., 1960.

Mining

Breaking, Blasting : *Research, Explosion.* Explosions Research Applied to Mine and Quarry Blasting. C. W. LIVINGSTON, *Min. Engg.*, Jan., 1960.

Breaking, Stope : *Uranium, Canada.* How Algom Operates a Jackleg Stope. L. H. BROWNE, *Engg. Min. J.*, Jan., 1960.

Coal, United Kingdom : *Applications, Electricity.* Some Aspects of the Application of Electricity to Modern Mining. T. M. MUIRHEAD, *Coll. Engg.*, Jan., Feb., 1960.

Coal, United Kingdom : *Hazard, Fire.* Dealing with an Underground Fire at Argyll Colliery. H. BURT, J. LAWRIE, *Trans. Instn. Min. Eng.*, Feb., 1960.

Coal, United Kingdom : *Planning, Development.* The Co-ordination of Surface and Underground Development at Peterlee, Co. Durham. W. D. DOBSON and others, *Trans. Instn. Min. Eng.*, Feb., 1960.

Education, Review : *Industries, Mineral.* The Future of the Mineral Industries. *Min. Engg.*, Jan., 1960.

General, Sweden : *Methods, Study.* Swedish Mines : Underground Mining Methods, A. PAUCARD, *Rev. d'Ind. Minerale*, Dec., 1959.

Handling, Conveyor : *Type, Assisted-Drive.* A Review of Belt Conveyors with Steel Haulage Members. D. S. KEDICK, T. FURMAN, *Coll. Engg.*, Jan., 1960.

Handling, Haulage : *Transport, Self-Loading.* Self-Loading Transport. J. CURRIE, *Min. World* (San Francisco), Jan., 1960.

Handling, Hoisting : *Coal, United Kingdom.* The Ryhope Friction Winder. *Coll. Guard.*, Feb. 4, 1960.

Handling, Hoisting : *Inspection, Rope.* The Theory and Practice of Electronic Testing of Winding Ropes. T. HARVEY, H. W. KRUGER, *Trans. S. Afr. Inst. Elec. Eng.*, June, 1959.

***Handling, Hoisting :** *Survey, 50-Year.* Fifty Years of Mine Winding. J. C. CHRISTIE, A. SHAW, THE MINING MAGAZINE, Feb., 1960.

Handling, Stockpile : *Iron Ore, Venezuela.* Orinoco Scraper Speeds Stockpile Feed. C. H. HUBBELL, *Engg. Min. J.*, Jan., 1960.

Handling, Transport : *Circuits, Shaft.* Standardization of Shaft Bottom and Shaft Top Minecar Circuits. F. H. LEE, *Coll. Engg.*, Feb., 1960.

Management, Principles : *Study, United States.* Kaiser Industries Corp. : Principles of Management. H. J. KAISER, *Min. Engg.*, Jan., 1960.

Mechanization, Underground : *Coal, United Kingdom.* Failures and Successes in Coal-Face Mechanization in a Highly-Mechanized Area. J. C. STEWART, E. B. PARK, *Trans. Instn. Min. Eng.*, Feb., 1960.

Opencast, Africa : *Copper, Northern Rhodesia.* Wheel and Belts Strip Nchanga Pit. *Engg. Min. J.*, Jan., 1960.

Opencast, Australia : *Uranium, Queensland.* The Mary Kathleen Uranium Project. A. NELSON, *Mine, Quarry Engg.*, Feb., 1960.

Opencast, United Kingdom : *Iron, Bedded.* The Development of Strip Mining in the Northampton Sand and Frodingham Ironstone Fields. T. M. DOVER, *Mine, Quarry Engg.*, Jan., 1960.

Sampling, Gold : *Control, South Africa.* Statistical Quality Control of Routine Underground Sampling. R. St.J. ROWLAND, H. S. SICHEL, *J. S. Afr. Inst. Min. Metall.*, Jan., 1960.

Ore-Dressing

Beach Sands, Australia : *Yoganup, Western.* Concentration of Beach Sand Minerals from Yoganup. S. B. HUDSON, C.S.I.R.O. Ore-Dressing Report No. 575.

Coal, Cleaning : *Slurries, Study.* Characteristics of Coal Preparation Plant Slurries. H. B. CHARMBURY, D. R. MITCHELL, *Min. Engg.*, Jan., 1960.

Coal, Preparation : *Dewatering, Research.* Studies in the Dewatering of Fine Coal. T. CARLEDGE and others, *Coll. Engg.*, Jan., 1960.

Comminution, Grinding : *Mills, Vibratory.* Vibration Mills and Their Application. G. GERTH, *Mine, Quarry Engg.*, Jan., 1960.

***Concentration, Gravity :** *Jigging, Review.* Jigging (I). Ore-Dressing Notes, THE MINING MAGAZINE, Feb., 1960.

†Flotation, Nonmetallics : *Coal, United States.* Kerosine Flotation of Coal. J. B. GAYLE and others, *Rep. Inv. U.S. Bur. Min.* 5528.

General, Australia : *Gold, Victoria.* Jig, Strake, and Flotation Concentration Tests on Ore from Wattle Gully Gold Mines. J. T. WOODCOCK, C.S.I.R.O. Ore-Dressing Report 573.

General, Congo : *Revierite, Recovery.* Rare Germanium Mineral—Revierite—Recovered by Magnetic Upgrading. L. STEYGERS, *Min. World* (San Francisco), Jan., 1960.

General, Mexico : *Silver, Pachuco.* Santa Julia Plant of Cia de Real del Monte y Pachuca. J. M. McGRATH, *Deco Trefoil*, Nov.–Dec., 1959.

General, Review : *Processes, New.* Minerals Beneficiation. N. ARBITER, *Chem. Engg. Min. Rev.* (Melbourne), Nov. 16, 1959.

†Progress, United States : *Survey, Education.* Minerals Beneficiation. N. WEISS, *Min. Engg.*, Jan., 1960.

Sand, Cleaning : *Glass, United States.* Simplot Washes High-Grade Glass Sand from Nevada Sandstone. J. B. HUTTL, *Engg. Min. J.*, Jan., 1960.